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GINKGO ADIANTOIDES (UNGER) HEER; CONTEMPORARY AND FOSSIL FORMS

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ONE PLATE AND EIGHT TEXT FIGURES

While studying the palæobotanic specimens of the Leningrad Section of the Research Oil Institute to identify the plant impressions collected by Geologist P. K. Ivanchuk in Miocene deposits near the village Krymskaya in the northern Caucasus, I found what I thought was a ginkgo. On further study I met with various contradictory opinions, of diverse authors, as to the specific Tertiary and Cretaceous peculiarities of this genus.

In past geologic epochs ginkgoes developed and spread rapidly over the world. Their earliest representatives are found in the Middle Devonian.[1] They attained their greatest development during the Mesozoic era, especially in the Jurassic period. No precise picture can be given of the evolution of the group in different geologic periods. The leaves, upon which the classification of ginkgoes is based, have no connection with generative organs and do not give us sufficient data. The Jurassic was the culminating period of the ginkgoes. In Cretaceous deposits they were mostly localized, filled small areas, and were less numerous than in the preceding period.

[1] *Psygmophyllum Kolderupii* Nathorst, from the Middle and the Upper Devonian in Norway, and *P. Kiltorkense* Johnson in Ireland [Kräusel (1926) and Zimmerman (1930)]. More recently some authors referred these species to the ferns, which demonstrates the fundamental difficulties of the systemization of ginkgoes in our study of these plants. In some cases it is scarcely possible to distinguish the leaves of the ginkgo from those of the fern.

From that time to the present there has been a continuous regression. The only living representative of this group is *Ginkgo biloba* Linnæus, which was first known only in cultivation, as a sacred tree in the gardens of some Japanese temples; at the beginning of the eighteenth century it was brought to European and North American botanic gardens.

Whether or not the tree has been preserved anywhere in a wild state is not yet clear. Seward and Gowan,(64, p. 109) according to the notes of travellers, quoted it for the forests that surround the sources of Gold River and the smaller Min in western China, and Lebunge Valley in southwestern China; but Pilger,(60) taking into consideration Wilson's descriptive notes,(80) considers this to be a misunderstanding due to confusion of Chinese names. That it is the sole living representative of what once was a vast group, makes the study of forms related to *Ginkgo biloba* interesting, and may shed light on its origin and determine the character and immediate causes of its regression.

In 1850 Unger described *Salisburia adiantoides*, a fossil species nearest to *Ginkgo biloba* Linnæus. For a time some authors used the generic name *Salisburia*, and others *Ginkgo*. The names are certainly synonymous.

This confusion of the names of fossil representatives has been caused by a similar misunderstanding with regard to the living representative, which was first described by Kaempfer,(27) under the name "Ginkgo." Linnæus(53) included it in his Mantissa plantarum (1771). In 1797 Smith found the name of the species "incorrect" and the generic name "uncouth," and changed the name of the plant to "*Salisburia adiantifolia*." For some time the latter incorrect name was used by botanists and also by Heer. Later Heer himself gave the species the correct name.

Heer,(13, p. 183; 14, p. 465) Pilar,(59, p. 23) Gardner,(10) and several other modern authors note the probable identity of *Ginkgo adiantoides* with the present species. However, they do not advance this opinion in a categorical form, partly for want of knowledge of its generative organs, partly owing to considerations of principle.

As it is, the classification of ginkgoes, based on the form and the lobulation of the lamina, is highly artificial, and in the modern species we find that these characters are subject to

many variations. The shape of the leaf of *G. biloba* differs according to its ecologic condition, the age of the tree, and its garden forms. Even in a single tree the shape of ginkgo leaves changes according to the age of the specimen, the position of the branch, and the position of the leaf on the branch.

We may cite the opinion of Seward and Gowan (64, p. 120) on this matter, as follows: ". . . a striking feature of Ginkgo-leaves is the variation in their size and shape, a fact insufficiently recognized by paleobotanical writers." In one of his latest works Seward (66) writes, on his observations of a series of leaves, on different branches and in different seasons, that it is unprofitable to utilize as characters of species lobulation or size of the lamina.

Elwes and Henry (8) are almost of the same opinion, describing garden forms of *G. biloba* Linnæus, many of which may be distinguished by the form of their leaves. They speak of lobulation as a character "scarce worthy of recognition," because leaves of all ginkgo trees possess variable lobulation.

Salfield (69) attaches no systematic importance to the lobe-shaped leaf of *Ginkgo biloba* Linnæus, and takes it as evidence of a diseased condition. Kräusel (39) holds another opinion; he refutes the possibility of disease being the cause of differentiated lobulæ and considers it possible that *G. biloba* owes this dissimilar form to influences of soil and climate; he asserts that the genus belongs to a cultivated species. Without refuting the influence of climatic, geologic, or ecologic factors in general in the formation of a given-shaped lamina, one cannot overlook the importance of artificial selection, which without doubt existed in former periods of the earth's history; but it is scarcely possible to indicate with any degree of exactitude what were the insiduous claims demanding the special development of the lobed leaf in the maidenhair tree held to be sacred in the Far East. We are in the dark as to how the genus came to be regarded as sacred. Light may be thrown on this subject by Sinologic study, which alone could explain the many questions as yet unanswered by botanists.

It is scarcely possible to prove that the differences between the European and North American specimens of ginkgo trees are due to artificial selection, as the tree itself has not been nurtured in those latitudes for more than three hundred years. It

is more likely that China furnished different ginkgo specimens to those countries, because the "striking features" of the ginkgo leaves are not included in any of the above suppositions.

Bailey,(1) in his studies of this tree, has solved the question and suggests that these peculiarities of foliage are "fitful recol-

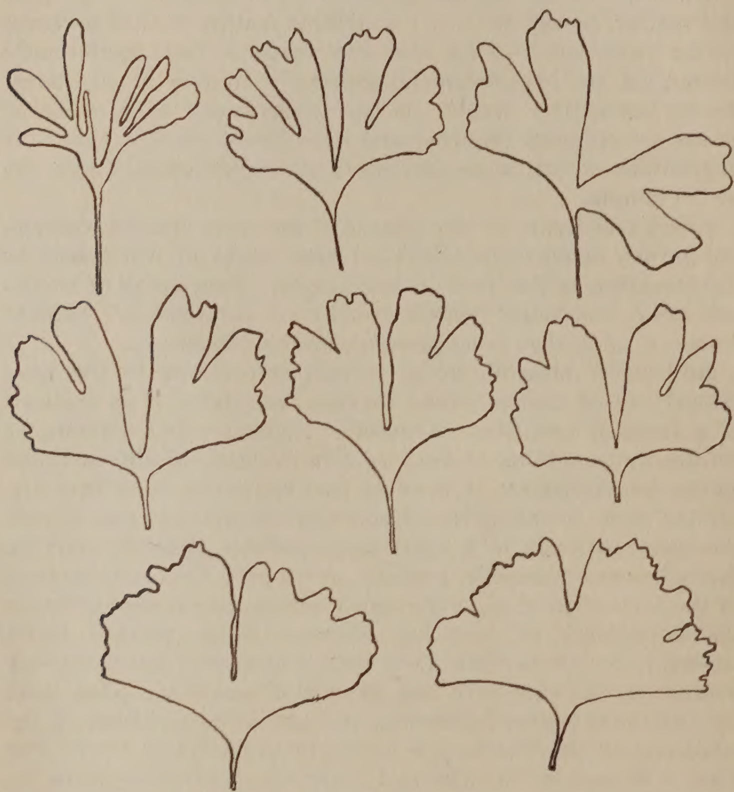

FIG. 1. Leaves of *Ginkgo biloba* Linnæus from the forest institution in Weener (Hannover). The leaves of the upper and middle rows belong to branches 1 year old; the lower row grew on older branches. [After Kräusel, Centralbl. für Mineral. (1917).]

lections of an ancient state," and Seward and Gowan (64, p. 197) also hold to the opinion that in some cases the deeply cut lamina of the leaf may be ascribed to genealogic heritage. As a proof of this statement they point to the fact that among Jurassic ginkgoes the lamina is of different shape, having narrower and more-numerous segments.

Fankhauser(9) and other authors prove that the first leaves of the seedlings of *Ginkgo biloba* Linnæus have a deeply cut lamina with a cuneiform base, and the following leaves of the plant have a more distinct lamina with a reniform base. This view is confirmed by some drawings of the leaves given us by Pilger(60, p. 98) as well as by an article of Kräusel(16) containing a few reproductions of the ginkgo leaf on branches of different ages. The leaves on the younger branches have a more elongate base with deeper sections, resembling the fossil *Baiera;* the leaves of the older branches of the tree are only slightly lobed, with a reniform base (text fig. 1).

In studying the leaves of *Ginkgo* in Adzharistan I was able to make the same observations, as may be seen in part in the accompanying photographs (Plate 1, figs. 1 to 3). A study of various species of *Ginkgo* shows that all ancient species have a more-dissected leaf, as is true of the genus *Ginkgo* on the whole in connection with the genus *Ginkgoales* of older origin; other groups prove that the segments of the lamina become narrower and filiform according to their more-ancient origin.

It is clear that the variation of the leaves of *G. biloba* Linnæus is a result of the biogenetic principle of Müller-Haeckel (ontogenesis repeats phylogenesis). There are fewer primitive characters on older specimens or shoots, and more on the younger ones. This matter has to be taken into consideration in describing the fossil ginkgo, in order to avoid confusion of the leaf with the leaves of other genera and species. A study of this species may show a higher percentage of primitive lamina forms among the impressions in older strata than in younger strata.

Chachloff(5) is of the same opinion as we are as to the evolution in the shape of the lamina of *Ginkgoales,* but explains this phenomenon in another manner. He writes:(5, pp. 17–18) "The degree of the deeply lobed lamina . . . proves that the number of the sections augments gradually from the genus Ginkgo L. to the genus Czekanowskia Hr . . . the genus Czekanowskia Hr. pertains to one phylogenetical branch Ginkgo-Baiera-Czekanowskia descendant of the genus Baiera R. Br." These deductions do not coincide with his former views on the subject and are certainly wrong, "as we know the most primitive and oldest representative of the Gingkgoales is the genus Ginkgo L., which appeared at the end of the carbon age . . . the most primitive

of the species with very slightly lobed leaf like the only genus of our day the genus Ginkgo biloba L." Evidently Chachloff has in view some of the specimens of ginkgoes of the Permian-Carboniferous period erroneously included in the genus *Ginkgo* (*G. martenensis* Ren., *G. cuneata* Schmalh., and others), as the shape of the leaves resembles that of the leaves of *Baiera*. Although Zalessky(83) called them *Nephropsis* and *Ginkgopsis*, their belonging to the *Ginkgoales* is doubtful.(61) It is impossible, therefore, to consider the beginning of the genus *Ginkgo* as belonging to any period before the Lias.(40) The mistaken idea of the history of *Ginkgoales* led Chachloff to commit more historic errors with regard to *Ginkgo*, the development of *Ginkgo biloba* Linnæus, and the general evolutionary process where the fundamental evolutionary force is natural selection. Therefore, the most primitive forms do not survive the process of evolution; contrary to Chachloff's opinion the most prominent divergence may be continued or eliminated by natural selection, becoming, in other words, nonprimitive.

As an illustration of the above a description may be given of the *Ginkgo* species as described by Heer and other palæobotanists. Special attention should be given to the group he mentions,(20, p. 34) as—"in all cases we have the right to affirm that *G. integriuscula*, *G. primordialis*, *G. reniformis*, *G. adiantoides* and *G. biloba* are closely tied in relationship to each other and in genetical connection." But in this case it is better to begin by mentioning a species older than the above group; namely, *G. digitata* (Brgn.) Heer. The leaf of *G. digitata* is characterized by a cuneate base and a deeply lobed lamina. The lobulation is so far differentiated that the most prominently lobed leaves are scarcely to be distinguished from those from species of *Baiera*, to which they will be probably related in time. Heer(19) describes *G. digitata* of Cape Boheman as having four distinct forms according to the number and character of their lobes.

Nathorst(57) does not agree with the age of the deposits given by Heer and states that they belong to the Middle Devonian, a later epoch, but he considers that none of these forms has any systematic significance, because one can see a consecutive gradation between them.

The most-differentiated forms of this species are so unlike the genus *Ginkgo* that Seward is right in pointing out the impossibility of distinguishing *Ginkgo* and *Baiera* from one another by the shape of their leaves. For this reason this species, or some of the specimens belonging to it, may be intermediate

between these genera; and some of the other examples given by Heer and other palæobotanists without doubt belong to other species of *Ginkgo*.

Nathorst considers *Ginkgo integriuscula* a variety of the same species. It was described by Heer as being of the deposits already mentioned; namely, Cape Boheman,(19, p.44) and a year later(20, p. 25) from the Jurassic of Ajakit. On closer inspection, however, any distinction between it and *G. adiantoides* seems doubtful. Heer's description is as follows: "*Ginkgo* f. basi attenuatis, semicircularibus, indivisis margine hike inde leviter incisis, nervis numerosis, pluriis dichotomis, flabellato-divergentibus."

The specimens, as seen in one of Heer's drawings,(20, pl. 6, fig. 5) show no greater sinuses in the leaves than *G. adiantoides*, and further comment in reference to the sinuses in other drawings seems scarcely possible owing to their being in a damaged condition. An elongated base, as already mentioned, must be the predominant feature among the ancient forms of *G. adiantoides;* as it may also be observed in later specimens, it would be erroneous to affirm the presence of some special variety, as all other characters fully coincide with the permanent form of *G. adiantoides*. Heer himself, in another instance, came to the conclusion that the cuneiform base cannot be taken as a sufficient proof of a special species. *Salisburia borealis* Heer, the species described by him as of the lower Eocene of Disko Island and Atanekerdluk(13, p. 95) and the Cretaceous of Mgatsch,(21, p. 21) was rightly characterized by a cuneate base. ("Ginkgo f. cuneiformibus, apicem versus sensium dilatatis.") But in Miocene Flora of Sakhalin(21, p. 21) he said: "At an earlier period I described this form as S. borealis, but consecutive transitions belonging to S. adiantoides, as well as to the form now existent, lead me to the conclusion that it belongs to the G. adiantoides." The age of these findings, incidentally, was erroneously determined by Heer as the Miocene; the age quoted in this article is corrected according to Kryshtofovich.(42; 44, p. 4)

Gardner(10, p. 99) as well as Seward,(67, p. 30) who studied the authentic specimen brought by Heer from Greenland in the Kew herbarium, consider the species *G. adiantoides;* and my careful study of the authentic specimens, also brought by Heer from Mgatsch and now in the Museum of the Botanical Institute of the Academy of Sciences in Leningrad, confirms this opinion. The specimen II–8 (text fig. 2) may better be classed as *G. digitata* (Brgn.) Heer, while the three other specimens show the

transitional development from a well-defined cuneiform to a typical reniform leaf.

One of the specimens from the Cretaceous deposits near Bureya River (35) has also a well-defined reniform base, while on the other impressions from the same locality may be seen a narrower base. Heer (20, p. 32) deduced a new species with a reniform leaf base from the Tertiary (Palæogene, according to Kryshtofovich) deposits Tschirimy-Kaja—*G. reniformis* ("Ginkgo f. reniformis margine hike inde leviter, incisis, nervis numerosis, pluriis dichotomis, flabellato divergentibus petiolo tenui."). He considers

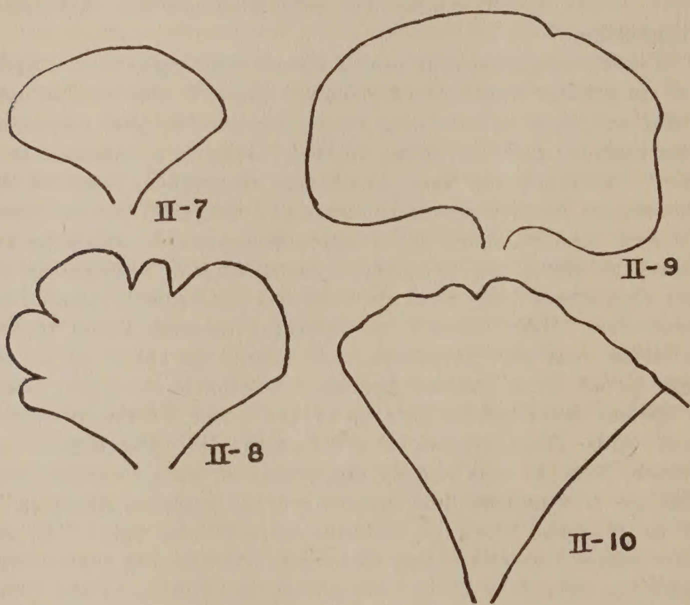

FIG. 2. *Ginkgo adiantoides* from Mgatsch. [After Heer, Flora foss. Arctica 5 (1878) pl. 2.]

the reniform base in this case as the principle character, but from my point of view I explain this phenomenon as being a sign of the later age of the deposits that contain this specimen. On closer observation of the given drawings (by Heer) we see a great difference between the venation of the leaves of *G. reniformis* (20, pl. 8, figs. 24, 25) and of the leaves of *Salisburia borealis*. (21, pl. 2, figs. 7–10) According to the drawings the latter seem to have a closer venation; but the original leaves, on careful study, prove to have the same venation as the leaves of *G. reniformis*.

Salisburia primordialis, of the Cretaceous of Atanekerdluk, (18, p. 100) is another species that Heer considers closely related to *G. reniformis*, because of the reniform lamina, although only part of the impression can be seen. For this reason Heer determines this species as an independent one, because the petiole at a distance of 1 centimeter from the lamina is seen as a small protuberance on a thicker axis of the 4-centimeter length. I think that this protuberance is due to crushing and not to normal growth. Seward, (68, p. 29) studying the original impressions in the Stockholm Museum, states that they have a longer axis, which probably has no connection with the leaf. For this reason I consider this impression to be *G. adiantoides*.

The study of the iconography of younger findings, by Heer, (24, pl. 87, figs. 9–12; 13, pl. 47, fig. 14) Ward, (77, pl. 31, figs. 5, 6) and Gardner, (10, pl. 25, figs. 1–5) gives a high percentage of well-formed reniform leaves. The same may be said of the impression of Kryshtofovich from the Eocene-Oligocene of Amagu River, (46, pl. 1, fig. 7) as well as those of Nathorst from the Senonian-Eocene of Svalbard (57, figs. 1, 2) where the cuneiform leaves are in excess by reason of their greater age.

The impressions figured by Heer from Atanekerdluk (14, pl. 45, fig. 1) and Puilasok (16, pl. 3, fig. 15) are very incomplete, and one may doubt their belonging to this species. A certain lobed configuration is noticeable in Gardner's magnificent specimens, as may also be seen in an impression of a Miocene specimen of Senigallia, which led Massalongo and Scarabelli to describe it erroneously as a new species—*Salisburia Procaccinii* Massalongo and Scarabelli. (56, p. 165, pl. 39, fig. 1) Schimper, (63, p. 356) Gardner, (10, p. 99) and Seward, (67, p. 30) as well as many other botanists, see no difference between this species and *G. adiantoides* (Unger) Heer.

The specimen of *Ginkgo adiantoides* (Unger) Heer of the Miocene deposits from Krymskaja Stanzia, found by Mr. Ivanchuk and lately studied by me, also shows a well-defined reniform base (Plate 1, fig. 4).

Among the impressions belonging to the Pliocene of Depape from St-Marcel d'Ardech and of Engelhardt-Kinkelin from Frankfurt on the Main, the two-lobed leaf is still better defined.

From the Laramie deposits Ward (77–79) described a new species, *G. laramiensis* Ward, as occupying an intermediate position between *G. adiantoides* and the contemporary species, *G.*

biloba Linnæus. Ward (79, p. 15) described *Ginkgo laramiensis* as follows: "Leaves small (3 to 5 cm. in width), narrowed to the petiole, the margin undulate, sinuate, or somewhat lobate; nerves flabellate-divergent, many times dichotomous."

"The occurrence of sinuses of variable depth at irregular intervals around the margins of the leaves is the chief distinction which separates this form from both *G. adiantoides* and *G. biloba*, between which it clearly holds an intermediate position." Ward's statement as to the intermediate position of the fossil between *Ginkgo adiantoides* and *G. biloba* was astonishing as the above-mentioned statements prove the unmistakable identity of these two species. Only the traditional views still held by palæobotanists have opposed the reduction of the name *G. adiantoides* to a synonym of *G. biloba*. There can be no question of an intermediate position where there is no interval.

Newsberry, as quoted by Ward himself, (79, p. 15) says that he "could find no sufficient characters to justify a specific distinction." In this connection Ward remarks: "There certainly is very little difference except in size, but between G. adiantoides and the living species there is not even that difference. I have therefore thought best to commemorate this small form by a separate name . . ."

In this case Ward's statement does not agree with what he wrote in the above where we read of *Ginkgo adiantoides* and *G. biloba* being intermediate. At the same time, it seems that these two species resemble each other more than either resembles *G. laramiensis*. Ward agrees that the difference between the species is slight, yet thinks it better to give the species a separate name. This is out of the question in view of the great variation of the leaves of *G. adiantoides* and *G. biloba*, noted earlier by Heer and by almost all the other specialists that have studied the ginkgo. Even the important characters—such as, sinuses and their depth, not to mention the size of leaf— are exceedingly variable. That species is also recorded by Knowlton (30, p. 31) from the Montana formation of beds included in the Laramie group.

Knowlton holds to Ward's opinion that the main difference is in size, "the leaves of *G. laramiensis* ranging from 30–40 mm. to 60–70 mm. in width and those of *G. adiantoides* from 75 mm. to 90 mm." Thus, the size of *G. laramiensis* is already augmented and equals the size of *G. adiantoides* for which the li-

mits are so abridged that one is obliged to think that the author in this case refers only to Gardner's specimens. In the shape of the leaf, Knowlton considers that the forms of this species are as different among themselves as those of the living species, and gives some drawings of the cuneiform and lobed leaf as well as the reniform and sinuous. He also affirms that the lamina of *G. laramiensis* does not seem as elongated towards the petiole as in *G. adiantoides*. This deduction, however, does not quite agree with his former opinion about the polymorphism of *G. laramiensis* leaves. The cuneiform base can be explained with success by assuming a more ancient origin, already mentioned. Comparison of the specimens given by Ward and Knowlton with the impressions of the same stratigraphic ages shows no difference in their shape. Seward(67) is right when he notes that *G. laramiensis* cannot be distinguished from *G. adiantoides* by any definite characters. Therefore, we have come to the conclusion that *G. laramiensis* is nothing but a synonym of *G. adiantoides*. In this way we may refer to a series of impressions from Sakhalin of the Cretaceous period, given by Kryshtofovich,(43, 45) as *G. laramiensis*.

In conclusion, a diagnosis of *G. adiantoides* may be given, taking into account the dynamism of the characters during a period of the life of this species.

Heer's(17, p. 14) diagnosis is as follows:

"f. late-rhomboideo-subreniformibus, in petiolum longum angustatis, margine undulatis, nervis flabellato-divergentibus pluriis dichotomis."

The diagnosis given by Massalongo and Scarabelli(56) is more complete, but also has some defects, as follows:

"f. late-rhomboideo-flabelliformibus, bipollicaribus in petiolum angustato-attenuatis, integris, apice undulato-sinuatis lobulatis flabellatim nervoso-striatis, nervis dicranodromis tenuissimi, strictis, parallelis sursum dichotomis."

The following table may be adduced to limit the species. The characters of the lamina shape are as follows:

In ancient forms.	In younger forms.
Fan-cuneate.	Reniform.
Dissected into two halves or incised to several more or less angular lobes.	Bilobed or entire.
With a cuneate bases gradually passing into a petiole.	Horizontal or cordate.

The diagnosis is as follows:

GINKGO ADIANTOIDES Unger sp. em. Shaparenko.

Salisburia adiantoides UNGER, Gen. et Spec. foss. (1850) 392.
Salisburia Procaccinii MASSALONGO and SCARABELLI, Fl. Senogall. (1858) 163.
Salisburia borealis HEER, Flora foss. Arctica 1 (1868) 95.
Ginkgo adiantoides (Unger) HEER, Flora foss. Arctica 3 (1874) 14.
Ginkgo primordialis HEER, Flora foss. Arctica 3 (1874) 100.
Ginkgo integriuscula HEER, Flora foss. Arctica 4 (1877) 44.
Ginkgo reniformis HEER, Flora foss. Artica 5 (1879) 32.
Ginkgo laramiensis WARD, Syn. of the Laramie Group (1885) 549.

Ginkgo foliis 3 ad 9 cm flabellato-cuneiformibus vel reniformibus; laminis subbipartitis vel multifidis vel subbilobis vel integris; margine irregularibus, undulatis vel planis; basi cuneiforme-angustatis vel subcordatis, nervis digitato-divergentibus numerosis dichotomis; interduum ductis secretoriis linearibus, nigris, brevibus, ab angulis nervorum excuntibus.

Ginkgo with leaves varying considerably from fan-cuneate to reniform; with lamina from dissected into two halves or incised into several more or less angulate lobes to bilobed or entire; with the base cuneate to cordate. Upper margin usually somewhat uneven and irregular in outline, undulated or plain. Leaves 3 to 9 centimeters wide, nerves flabellate-divergent, numerous, often dichotomous, occasionally with short secretory canals seen as short dark lines coming from the forks of the veins.

A chronologic table of the finds of *Ginkgo adiantoides* Unger sp. em. Shaparenko is given here. This paper and the following table do not give a detailed account of the ginkgo, but everything quoted has been minutely studied under special control and mistakes have been eliminated or given with an interrogation mark.

List of finds of Ginkgo adiantoides (Unger) sp. em. Shaparenko.

THE JURASSIC.

Ajakit, Siberia. Heer (1878) (1) 25, pl. 6, figs. 5, 6. "*G. integriuscula.*"
Cape Boheman, Svalbard. Heer (1877) 44, pl. 10, figs. 7–9; Heer (1878) (1); Nathorst (1919) considers this find between the Jurassic and the Cretaceous (Portlandian-Wealden).

THE CRETACEOUS.

Mgatsch, Sakhalin. Heer (1878) (2) 21, pl. 2, figs. 7–10. "*S. borealis.*" Heer gives mistaken data in referring this find to the Miocene. Kryshtofovich (1918); (1921) (1) 4.
Makai, Sakhalin, Japan. Kryshtofovich (1918).
Atanekerdluk, Greenland. Heer (1874) (3) 100, pl. 27, figs. 1–3; (1882). "*S. primordialis.*"

THE UPPER CRETACEOUS.

Bureya River, Siberia. Konstantow (1914) pl. 4, figs. 2, 5, 6. Erroneously refers to the Miocene (Kryshtofovich (1931).

Alexandrovka River, Sakhalin. Krystofovich (1921) (2). "*G. laramiensis.*"

Ludvigova pady, Sakhalin. Kryshtofovich (1921).

Nainai River, Sakhalin. Kryshtofovich (1921).

Komarinyi source, Sakhalin. Kryshtofovich (1921).

Point of Rocks, Wyoming. Ward (1884–5) pl. 31; (1887). "*G. laramiensis.*"

South Dakota. Knowlton (1911). Lance formation.

Glasgow, Montana. Knowlton (1911). Lance formation.

Sand Creek, above Glendive, Montana. Knowlton (1911). Lance formation.

Weston County, Wyoming. Knowlton (1911). Lance formation.

Big Horn Basin, Wyoming. Knowlton (1911). Lance formation.

THE TERTIARY. The lower strata (Eocene, possibly the Cretaceous). Conventional symbol on the map: "1."

Braganza Bay, Svalbard. Nathorst (1919).

Green Harbor, Svalbard. Nathorst (1911).

THE PALÆOGENE. Conventional symbols on the map: "2–4."

Uglovaia Bay, Siberia. Stempel (1926).

Tschirimyi Kaja, Siberia. Heer (1878) (1) 32, pl. 8, figs. 24, 25. "*G. reniformis.*"

THE LOWER EOCENE.

Atanakerdluk, Greenland. Heer (1868) pl. 47, fig. 14; (1869) (1) pl. 44, figs. 1–?; (1874) (2); (1883). "*S. borealis.*"

Disko, Greenland. Heer (1874) (1) pl. 3 figs. 15–? (1874) (2); (1883); (1868) pl. 2 fig. 1; "*S. borealis.*"

Hasen, Greenland. Heer (1883).

(Mistaken data of all three as the Miocene.)

Seven Mile Creek, near Glendive, Montana. Ward (1884–5) pl. 31, figs. 5, 6.

THE EOCENE OR OLIGOCENE. Conventional symbols on the map: "3–4."

Mgatsch, Sakhalin. Krystofovich (1921) (4).

Dui, Sakhalin. Kryshtofovich (1921) (4); (1918).

Amagu River, Siberia. Kryshtofovich (1921) (1) 11; (1921) (2); (1921) (3).

Sitka, Alaska. Knowlton (1894) (1); (1894) (2). The Eocene.

Herendeen Bay, Alaska. Knowlton (1894) (1); (1894) (2). The Eocene.

Porcupine Creek, Alberta. Knowlton (1919). The Eocene.

Great Valley, Alberta. Knowlton (1919). The Eocene.

Tulamen, British Columbia. Knowlton (1919). The Oligocene.

Horsefly River, British Columbia. Knowlton (1919). The Oligocene.

Samland, East Prussia. Heer (1868); (1869) (2) 11. (?)

Ardtun Head, Isle of Mull. Gardner (1886) pl. 25, figs. 1–5. The Eocene.

Bovey-Tracey, England. Heer (1861). The Eocene.

Sterlitamak, Bashkiria. Kryshtofovich (1932) (1).

THE MIOCENE.

Krymskaja, Northern Caucasus. Collected by P. K. Ivanchuk.

Dolja, Yugoslavia. Pilar (1883).

Senigallia, Italy. Massalongo and Scarabelli (1858) "S. adiantoides," pl. 39, fig. 12, pl. 7, fig. 2, pl. 6, fig. 13; "S. Procaccinii," pl. 39; Unger (1845, 1847).

Parschlug, Styria. Unger (1845, 1847, 1848, 1850).

THE PLIOCENE.

St. Marcel, France. Depape (1913, 1922). The Lower Pliocene.

Privas, France. Boulay (1887); Depape (1913).

Klarbecken, Germany. Engelhardt and Kinkelin (1911), pl. 23, fig. 18, *a*. The upper Pliocene.

THE QUARTERNARY.

The homestead Astashikha (mouth of Bureya River). Kryshtofovich (1915, 1932) (2).

In studying the large area from which *Ginkgo adiantoides* is mentioned in the foregoing list one is struck by the incompatibility of climatic conditions in which *G. adiantoides* grew in former days, as compared with the present climatic zones in which the remains of the ginkgo are found. Apparently the biology of the ginkgo now extant, by which we determine the fossil, is to a great extent unlike the latter, or the climatic zones in the past geologic epochs were subjected to great shifting. The first supposition is very unlikely. It is difficult to fix a certain regularity in the wide-spread growth of *Ginkgo adiantoides* and the solitariness of geographic points, in which its traces are found. This solitariness, when we observe it in one continent, is undoubtedly due to want of knowledge of the fossil flora.

However, it is more difficult to explain the wide distribution of the ginkgo, considering the geographic barriers in the way of its diffusion. Here must be pointed out the methodologic mistake causing the difficulty; namely, the study of palæogeographic questions with contemporary maps. Land vegetation of ancient geologic periods should be studied and determined according to maps of the periods in question. The facts already quoted might be explained most clearly by the distribution of dry land and climatic zones in the manner proposed by Köppen-Wegener's theory.(38) The isolated habitats of *Ginkgo adiantoides* as perceived in that light are latitudinally situated in geographic parallels of corresponding geologic periods. A glance at a contemporary map showing latitudes of the ancient geologic periods (text fig. 3), which I have computed according to Köppen-Wegener, and at the finds of *G. adiantoides*, shows a well-

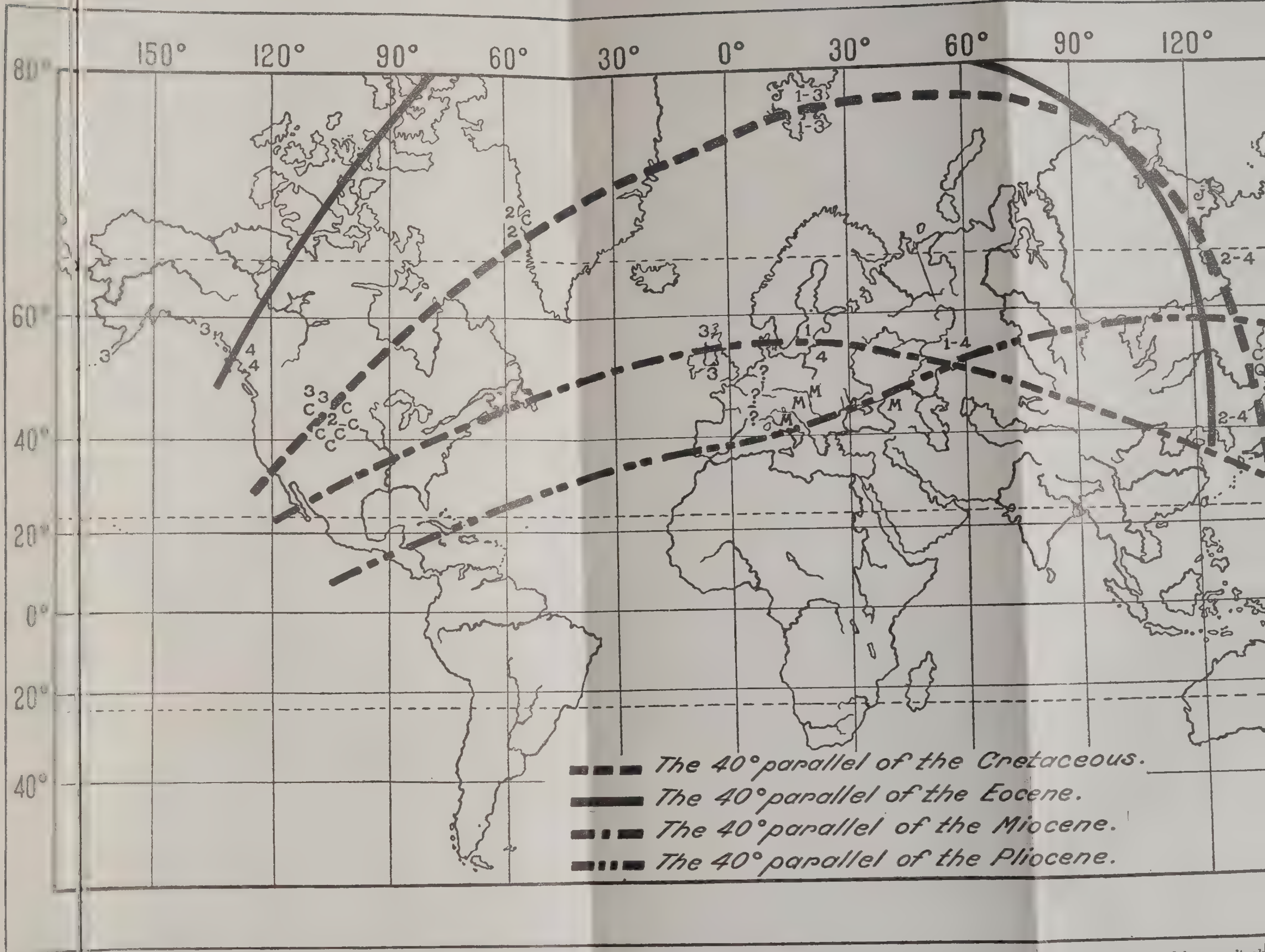

FIG. 3. [illegible] of *Ginkgo adiantoides* Unger and position of the 40° parallel in different geologic epochs, according to Köppen and Wegner. The 40° parallel of the jurassic is not plotted because it al[illegible] ceous. The [illegible]rs and numbers refer to ages of locations in sequence, as follows: J, Jurassic; C, Cretaceous; 1, Cretaceous or lower Eocene; 2, Lower Eocene; 3, Eocene; 4, Oligocene; M, Mio[illegible] Hyp[illegible] [illegible]bers refer to ages of locations not precisely determined.

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defined connection in the latter, so that the acceptance of this theory is justified in the present treatise.

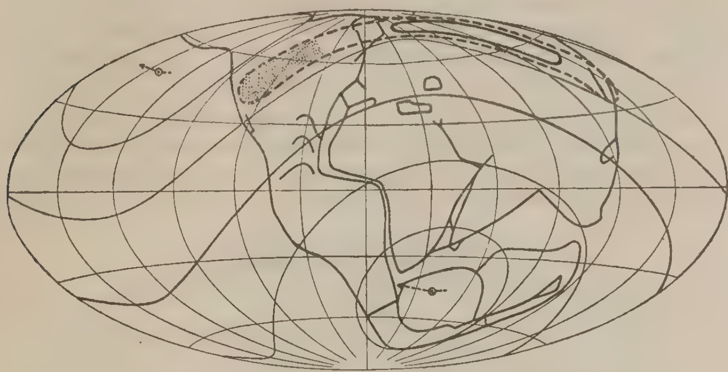

FIG. 4. Areas of *Ginkgo adiantoides* Unger in different geologic periods. The geographic network (0°, 30°, 60°) and the shapes of the mainlands are those of the Cretaceous.

FIG. 5. The Cretaceous and the Eocene-Oligocene areas. The geographic network and the shapes of the mainlands are those of the Eocene.

The most ancient finds of this species (Ajakit, Cape Boheman) are located in the tertiary of Angarida, seemingly the center of the growth of this species. According to Wegener this region should have lain at about 40° north latitude, which almost coin-

cides with the latitude of the area of the living species now growing in a half-wild state.

We come upon fossils of *G. adiantoides* in the Cretaceous outside this region; for example, in the Cretaceous and Upper Cretaceous of the Far East, in the Cretaceous of Greenland and in the Upper Cretaceous localities in Montana, Wyoming, and South Dakota (text figs. 3 and 4). Greenland and North America and ancient Angarida must have been connected by dry land to explain the diffusion of this species, unless we consider it as being of pantropic origin, for which we have no foundation.

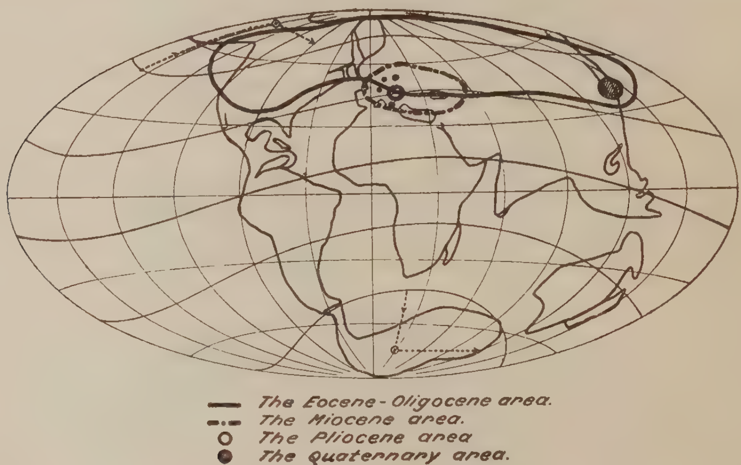

FIG. 6. The Eocene-Oligocene, Miocene, Pliocene, and Quaternary areas. The geographic network and the shapes of the mainlands are those of the Miocene.

Knowlton (33, pp. 44 and 45) remarks that the seeds of the gymnosperms of that period, including the ginkgo, cannot withstand sea water for any length of time; hence, dissemination by way of ocean currents is improbable. Knowlton is mistaken in considering that Mammifera did not exist among the fauna of that period;[2] but they were as yet imperfect and not widely distributed, and therefore cannot be looked upon as a serious factor in the diffusion of seeds; *Archæopteryx* was the only avian genus represented. The seeds could not have been transferred by the wind to any great distance as they were not supplied with pappus or other means by which they could be carried; therefore,

[2] The first signs of the Mammifera are traced in the Jurassic; that is, Multituberculata, Polyprobodontia, and others. See Yakowlew (1932).

the only seemingly valid theory is that of a land connection then existing between the continents. As may be seen by Wegener's scheme there must have been an indissoluble connection between these points, broken only in the Quaternary period when Greenland and North America were detached from Europe. One must also take into consideration the propagation of the species in unrelenting conformity with the zonal low towards the East and South of the Angar center. No obvious change in the meridional direction has been noted in the period between the

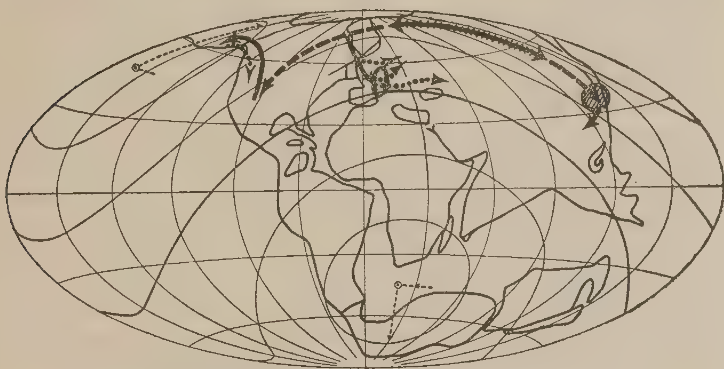

FIG. 7. The distribution of *Ginkgo adiantoides* Unger in different geologic periods. The geographic network and the shapes of the mainlands are those of the Eocene. The distribution was effected by means of the connections between continents. The map shows the progress of distribution during the Jurassic, the Cretaceous, and the Eocene, the region in which the plant was localized during the Oligocene-Miocene, the ginkgo area which remained in Europe to the end of the Pliocene, and the Quaternary ginkgo area.

Jurassic and the Cretaceous, and according to Wegener climate changed very little during that time.

In the lower Tertiary we find the ginkgo in the region of its primary center (Tschirimy-Kaja, Svalbard). According to Wegener the climatic changes to the Eocene on this part of the 40th parallel were insignificant as to cold (figs. 7 nd 8), which may explain the growth of the ginkgo in the same area; it may be slightly tending towards the Equator (seen on a contemporary map to the south; Amagu River, Uglovaia Bay). One may

follow a more-pronounced trend in North America (Seven Mile Creek in the lower Eocene; Green Harbor; Porcupine Creek, Herendeen Bay, and Sitka, in the Eocene), but only in a contrary path northward. In the Tertiary of North America, according to Wegener, a greater change could be remarked towards warmer conditions, which reached their culminating point in the Eocene. Violent changes towards cold in the Miocene characterized the climate of the Eurasian continent with the exception of its extreme southeastern limit. North America proves to have experienced the cold to a less extent. These changes and consequent glaciation were the cause of the ginkgo's migration in a converse direction. *Ginkgo adiantoides* thrived in the latitude corresponding to British Columbia and we find it also in Sterlitamak. British finds belong either to this period or represent somewhat more of the species resistant to heat, which had penetrated in the Miocene in territories where the heat was too great at that time (30th parallel). The last supposition may be true, as we find *G. adiantoides* in the Miocene of Europe in a latitude south of 40° (Krymskaja, Dolja, Senigallia, and Parschlug; text figs. 3 and 5). In the greater part of Asia and America the climatic change to cold was so great as to exterminate *G. adiantoides* before its migration to the south could be effected, because of the massive range of mountain land in central Asia and the vast plains of North America. Wegener's theory throws light on the matter and explains all the questionable points in the palæogeographic history of plants. Towards the end of the Tertiary—that is, the Pliocene—*G. adiantoides* was unable to cope with the cold, which eventually caused its extinction in America. There remains a small isolated patch of land where we see the latest and seemingly the last remains of *Ginkgo adiantoides* in Europe (text fig. 6). The great glaciation advancing from the northwest abolished the Pliocene flora of the northern and western parts of the mainland or forced it to migrate to the southern borderlands of the Eurasian and North American mainlands.

A study of the climatic and geographic elements that *G. adiantoides* was obliged to meet in those borderlands is necessary in order to understand its further distribution. In the Mediterranean the Tertiary flora was abolished by an earlier advanced exsiccation, after which the land became the shelter of a special Mediterranean flora.(43) The alluvial plains near the Pyrenees, the plains of the Cordilleras, and the affluent tributa-

ries of the Mississippi, in their climatic conditions, seemingly proved unsuitable for *Ginkgo*. Climatic conditions in this periglacial zone, in the glaciation of the mainland as well as of the interior mountains, as described by Tutkowsky(72) and later by Brooks(4) and Hobbs(25) [see also Litchkov (1931) and Grigoriew (1930)], were characterized by cold dry winds blowing from the ice fields and destroying all vegetation. Whether deserts with a hot climate have ever existed, as supposed by Tutkowsky, or peculiar dry regions with a frosty climate, as maintained by Hobbs, by Litchkov, and by Grigoriew, and named by the last "Arctic Steppes," is of no vital importance to us, insofar as these scientists agree on the point characterizing these regions as "dry," making them unsuitable not only for *Ginkgo adiantoides*, but also for all afforestation. According to Litchkov the northern part of the Eurasian mainland in the Quaternary presented an almost continuous chain of ice fields from Scandinavia to Enisey River, south of which lay great alluvial plains. Opposed to these in consecutive order lay a second chain of alluvial plains formed by the ice-bound Caucasus, Pamir, Tian Shan, and Altai Ranges, almost in touch with the former. These plains gave rise to the wilderness of our day and the steppes of Manitcha, Karakouma, Kisil-kouma, Semiretchie, and Koulounda. Litchkov(54, p. 99) gives us the following:

"We may think that the great territories of the U. S. S. R. in Europe and in Western Siberia as well as the plains of the Touran—collosal alluvial plains, are created by the waters proceeding from the ice-fields of the mainland's glaciation in the North and those of the mountain ice-fields in the South [text fig. 8].

"Looking at this question in that light it is possible to conceive the well known zoögeographical fact that the limit for the fauna, separating Europe from Asia does not run along the Ural, but much further to East—along the Enisey. The reason of this seems clear as the great alluvial plains terminate at the Enisey, after which begins the lofty watershed plateau."

The ice-bound territory in eastern Asia was not so large as in Europe or western Siberia,(54, p. 100) for its configuration and seaboard made climatic conditions less continental but warmer and damp (Grigoriew).(11, p. 89, 90) The conditions in this place were more favorable for the preservation of *Ginkgo* in the Quaternary, and here in eastern Asia the Quaternary

FIG. 8. Glaciation of the Quaternary in Eurasia. The map shows the ancient glaciations of mountains and mainlands and the ancient alluvial plains. [After Litchkov (1932), Tolmatchev (1931), and others.]

remains of *Ginkgo adiantoides* (in the farm of Astashikha, not far from the mouth of Bureya River) were found.(41, 52) In this zone existed the possibilities of a wider throw and quicker migration south from the ever-increasing cold; here also there was the least change in climatic conditions; but, notwithstanding these facts, the ginkgo could not have contended long with the gymnospermous flora, which had by that time reached a luxurious development, but was doomed to die out if there had not appeared in the Quaternary a new and mighty factor, which interferred in the balance of nature; namely, man and his culture. That culture came from the East, and with it the struggle for life and natural selection underwent a radical change, the latter to a great degree giving way to artificial selection or change in character. Biologic processes in nature change their course according to the direct or indirect will of man. Some plants are ruthlessly destroyed, others are on the path to extermination, but if able to serve him for some given profit are saved, cultivated, and borne through all the continents, losing the elements that at first tied them to their natural home and primordial forms as may be seen in many examples of vegetable life and as well in *Ginkgo adiantoides*. At present *Ginkgo adiantoides* is cultivated and growing in almost all botanic gardens of Europe and North America, winning back its former areas and glory.

Such is the evolution of *Ginkgo* in different geologic epochs. It is, however, but a fragment from the leaf of time that could be devoted to the whole group of the ginkgoes; as yet the systematically organized analysis necessary for such an extensive task is lacking. Therefore, it is interesting to make a comparison of some deductions based upon the study of our little group with analogous investigations of the cycads and conifers.

Koch(36) demarks the origin of the conifers as being in the center of the territory adjacent to the Carboniferous equatorial belt. The species need heat far more than the ginkgoes. In the period when *Ginkgo adiantoides* came into being in the Jurassic the cycads had already migrated from subtropical Europe and penetrated North and, later, South America as well as adjacent islands. They penetrated East Africa, Madagascar, India, and Australia, which formed at that period one continent. The cycads migrating from East Africa to Australia did not attempt to thrive in the Antarctic Continent in apposition to the conifers,

which, coming into being at a later period after the subdivision of the African Continent and the falling away of Madagascar, India, and Australia, were able to penetrate only through the Antarctic Continent. The diffusion of our species of *Ginkgo* began later in the Cretaceous, by reason of which it could penetrate no farther than North America and eastern Asia. According to Koch the cycad during its diffusion coincided with the shifting of the subtropical zones, which is true also of the ginkgo. Koch holds to the same opinion as we do, according to which the cycad began to die out during the Eocene shifting of the pole to the neoteric.

Interesting deductions may be made from Studt's history of the conifers (70) as seen in the light of Wegener's theory. Studt is of the opinion that the conifers came into being in the northern extratropical zone and divides the development of the species into three phases: The first, from the Carboniferous to the Triassic, before the appearance of our species; the second phase coinciding with the appearance of our species, characterized by the wealth of the conifers, in Europe; the third phase falls in a colder period, which caused the extinction of conifers in Europe, although Studt notes that they might have been preserved in eastern Asia and North America. Studying the shift of the areas in different geologic periods Studt observes their asymmetry, pointing to the fact that for many kinds of species migration took place in Europe and North America, excluding eastern Asia.

Both Studt and Koch agree with Wegener's theory and believe that all the mainland formed one unit until its shift in relation to the pole and disintegration into smaller continents.

In conclusion I should like to express my obligations to Professor Palibin, who has kindly favored me with valuable suggestions during the course of my work, and to Professor Wulff, to whom I am deeply indebted for giving me further incentive in my work on geographic research.

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ILLUSTRATIONS

PLATE 1

FIG. 1. *Ginkgo biloba* Linnæus, from Adzharistan; leaves belonging to a 1-year-old plant.

2. *Ginkgo biloba* Linnæus, from Adzharistan; leaves belonging to a 2-year-old plant.

3. *Ginkgo biloba* Linnæus, from Adzharistan; leaves beloning to an old plant.

4. *Ginkgo adiantoides* Unger, from Krymskaya Stantzia.

TEXT FIGURES

FIG. 1. Leaves of *Ginkgo biloba* Linnæus, from the forest institution in Weener (Hannover). The leaves of the upper and middle rows belong to branches 1 year old; the lower row grew on older branches. [After Kräusel, Centralbl. für Mineral. (1917).]

2. *Ginkgo adiantoides* Unger, from Mgatch. [After Heer, Flora foss. Arctica 5 (1878) pl. 2.]

3. Locations of *Ginkgo adiantoides* Unger and position of the 40th parallel in different geologic epochs, according to Köppen and Wegener. The 40th parallel of the jurassic is not plotted because it almost coincides with that of the Cretaceous. The letters and numbers refer to ages of locations in sequence, as follows:

J, Jurassic.	3, Eocene.
C, Cretaceous.	4, Oligocene.
1, Cretaceous or lower Eocene.	M, Miocene.
	P, Pliocene.
2, Lower Eocene.	Q, Quaternary.

Hyphenated numbers refer to ages of locations not precisely determined.

4. Areas of *Ginkgo adiantoides* Unger in different geologic periods. The greographic network (0°, 30°, 60°) and the shapes of the mainlands are those of the Cretaceous.

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6. The Eocene-Oligocene, Miocene, Pliocene, and Quaternary areas. The geographic network and the shapes of the mainlands are those of the Miocene.

7. The distribution of *Ginkgo adiantoides* Unger in different geologic periods. The geographic network and the shapes of the mainlands are those of the Eocene. The distribution was effected by means of the connections between continents. The

map shows the progress of distribution during the Jurassic, the Cretaceous, and the Eocene, the region in which the plant was localized during the Oligocene-Miocene, the ginkgo area which remained in Europe to the end of the Pliocene, and the Quaternary ginkgo area.

FIG. 8. Glaciation of the Quaternary in Eurasia. The map shows the ancient glaciations of mountains and mainlands and the ancient alluvial plains. [After Litchkov (1932), Tolmatchev (1931), and others.]

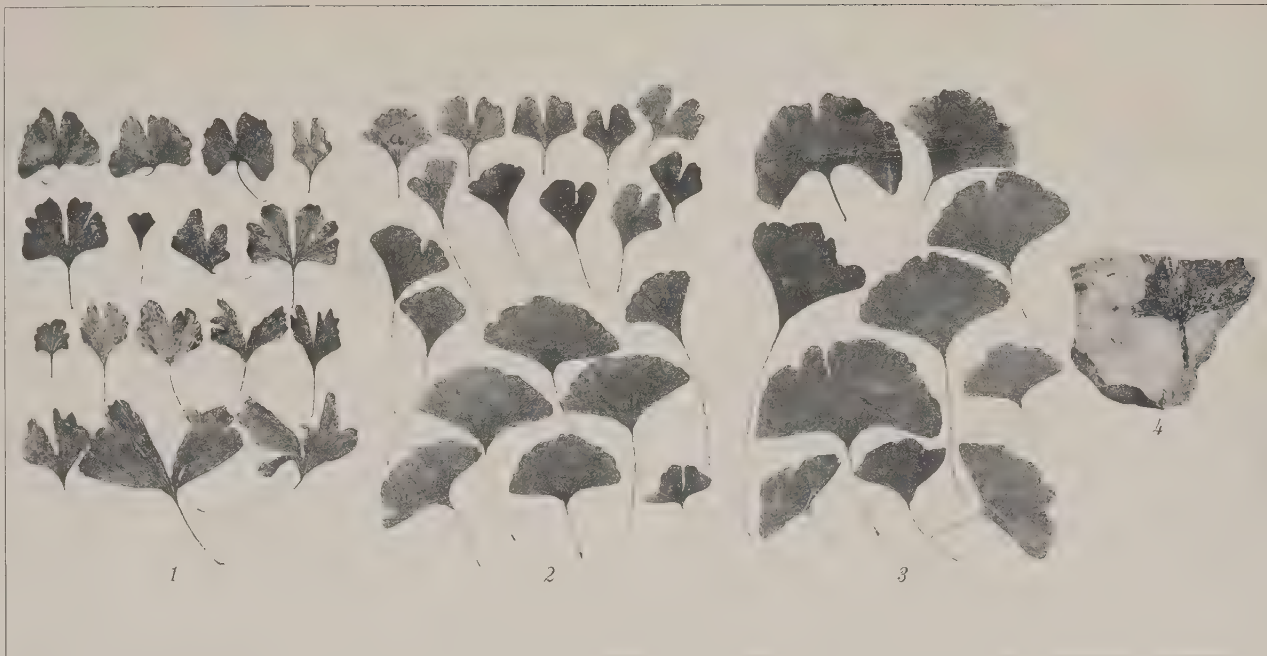

PLATE 1.

CONTROL OF BACTERIAL FRUITLET ROTS OF THE PINEAPPLE IN THE PHILIPPINES [1]

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ONE PLATE AND TWO TEXT FIGURES

INTRODUCTION

The bacterial fruitlet rots of the pineapple,(14, 15) particularly the fruitlet black-rot of the Smooth Cayenne variety caused by *Phytomonas ananas* Serrano, are the worst diseases known to affect pineapple fruits in the Philippines.

From 1927 to 1930 between twenty-seven and fifty-five of every hundred fruits were found infected to a greater or lesser degree by either one or both of the maladies, twelve or more of which generally represented a total loss. As the destructive effects of such infections are enough to cause serious apprehension with regard to the future of the industry, the exploitation of all possible ways and means of control was undertaken as presented in this report.

FACTORS FAVORING FRUITLET ROTS

A more or less thorough study of the different phases of the problem revealed that there are at least four factors—two agronomic, one environmental, and one physicochemical—that favor these diseases; namely, incomplete closing of the eyes, fewness of shoots, high temperature, and low acidity of the fruit.

Incomplete closing of the eyes.—The "eyes" in which the flowers are inclosed prior to and during blooming time represent in reality the outgrowth of the fruitlets composing the fruit. They are covered with bracts, which remain partly open during anthesis and close more or less completely as the flowers begin

[1] This paper is a continuation of the two papers on the bacterial fruitlet rots of pineapple published in the Philippine Journal of Science. (14, 15)

[2] The writer wishes to express his gratitude to the Philippine Packing Corporation for its valuable help in carrying out the field investigations. Thanks are also due Dr. G. O. Ocfemia, of the College of Agriculture, Los Baños, for reading the manuscript.

to wither. There are individual fruits, however, that do not entirely close their eyes even at maturity, either because of a natural-inherited trait, or because of some physiologic disturbance or pathologic affliction. Such loose-eyed fruits were found more heavily infected by the bacterial fruitlet-rot diseases than the tight-eyed fruits.

Fewness of shoots.—Strains of the Smooth Cayenne variety were found to vary in their capacity to produce suckers, shoots, hapas, and slips. The strain that produces an abundance of shoots around the fruit holds the fruit erect, with its crown protecting it more or less from direct sunlight; whereas the strain with but a few shoots generally has the fruit inclined or bent to one side, exposing the upper side to the direct heat of the sun. This exposure to the direct heat of the sun raises the temperature of the fruit, scorching it sometimes and creating a favorable condition for the activities of those bacterial pathogens that require a high temperature for their optimum development.

High temperature.—Experiments have shown that the optimum temperature for both *Phytomonas ananas* Serrano(14) and *Erwinia ananas* Serrano(15) lies between 31° and 33° C. Actual field observations show that during the hot months of the year and in places where the average daily temperature is high, the bacterial fruitlet-rot infections are more prevalent. Therefore, plantings at lower elevations are more severely attacked than those at higher elevations or about 2,000 feet above sea level, where the average daily temperature is comparatively low.

Low acidity of the fruit.—Of all the factors favoring the incidence of bacterial fruitlet rots, particularly the fruitlet blackrot caused by *Phytomonas ananas* Serrano, perhaps the most important is low acidity in the fruit. Wells et al.,(22) in their article on the composition of Philippine pineapples, reported that the healthy fruits are more acidic than the diseased fruits; that a comparison between the fruits of the native varieties and those of the Smooth Cayenne, between the large and the small fruits, between the shaded and the exposed fruits, and between the upper half and the lower half of the fruits, revealed that individually or collectively, the first is more acidic than the second in every case. Both field and laboratory studies have shown that fruits or parts of fruits with higher acidity suffer less from the ravages of the bacterial fruitlet-rot diseases. These observations seem to agree well with the results obtained from the cultural studies of the bacterial pathogens(25, 26) that

an acidity of about pH 3.7 is strong enough to inhibit their growth and development, their optimum reaction lying between pH 5 and 6.

It was also noted that no fruits as acid as pH 3.7 or more showed any infection. This evidence explains why, in Hawaii, where the acidity of the Smooth Cayenne fruits averages between pH 3.6 and 3.8, the bacterial fruitlet-rot diseases are mild.

CONTROL MEASURES

It seems that elimination of the favorable factors would greatly minimize the ravages of the diseases. Previous experiments(14, 15) have shown that the bacterial pathogens gain entrance into the fruitlets during the development of the fruit through different avenues; namely, through decaying flower parts, through ruptured fissurelike slits running from the eye cavities to the placental lobes, and through mechanical cracks that are generally present in the eye cavities of large succulent fruits. These facts suggest the possibility of immediate control through the use of fungicides during fruit development. Spraying was, therefore, tried, first alone, and then hand in hand with other experiments aiming at the elimination of factors favoring these maladies.

SPRAYING

Several fungicides, such as Bordeaux mixture, lime-sulphur, copper sulphate, mercuric chloride, and Semesan, of various concentrations, were tried at different times and in different localities.

EXPERIMENT 1

The first field trial was made in Calauan, Laguna Province, Luzon, in February, 1927, and the second in Makar, Cotobato Province, Mindanao, in March, 1928; lime-sulphur was used in both cases. There was practically no rain during the days covered by the spraying calendar. There was, however, fairly high humidity, as is typical of the locality.

Materials and methods.—The Smooth Cayenne field used in Calauan, Laguna, consisted of six single rows about 100 meters long and about 1 meter apart, with the plants in the rows spaced at 0.5 meter. With a compressed-air sprayer (Plate 1, fig. 1) spraying was started as soon as the flowers began to open. Row 1 was sprayed weekly for two months with tap water as check; row 2, weekly for two months, with lime-sulphur (33°

Baumé) at 1: 40 dilution; row 3, biweekly for two months, with 1 : 40 lime-sulphur; row 4 monthly for two months, with 1 : 40 lime-sulphur; row 5, weekly for two months, with 1: 60 lime-sulphur; and row 6, weekly for two months, with 1: 80 lime-sulphur. In every instance care was taken to cover thoroughly the flowers and small leaves around the fruit with the fine mist of the spray solution.

In the second field trial made in Makar, Cotobato, 1: 70 lime-sulphur (33° Baumé) was used at weekly intervals for two months on every other double row (56 by 22 by 18 inches) in a trial field of Smooth Cayenne belonging to the Philippine Packing Corporation, leaving the alternating rows unsprayed as check.

Results.—The fruits were picked by the row after approximately five months or as soon as signs of ripening were noticed, cross-cut into slices 1 to 2 centimeters thick, and all internal discolorations noted as shown in Table 1.

The results obtained from the preliminary spraying experiments, as shown in Table 1, strongly indicate that bacterial fruitlet-rot infections can be reduced to the minimum by spraying, and that lime-sulphur spray offers great possibilities as an effective means of control. It may be noted that a 1: 70 lime-sulphur (33° Baumé) solution applied weekly for two months during the blooming period gave the most effective control. On the other hand, a 1 : 40 dilution was not as effective, and produced considerable scorching on flowers and tender leaves and a decided stunting of the fruits.

EXPERIMENT 2

Experiment 2 was conducted in the pineapple plantations of the Philippine Packing Corporation in Bukidnon Province to compare the efficiency of lime-sulphur and Bordeaux mixture. The lack of sufficient plant material at the time prevented the writer from including various kinds of sprays as originally planned. Hence, only three series were included in this experiment, conducted at different times. The first was conducted in September, 1928, and the second, in April, 1929, both at Diklom, Tangkulan; the third was carried out in April, 1929, in field 1 at Santa Fe. The first happened to coincide with rather wet days, and the second and third, with moderately dry days.

Materials and methods.—In the first series Bordeaux mixture of 3–3–50 formula was compared with lime-sulphur (33° Baumé) of 1: 70 dilution; the former was applied thrice a week for five

TABLE 1.—*Results of lime-sulphur spraying for the control of bacterial fruitlet rots.*

Locality.	Spray solution.	Dilution.	Frequency of application.	Fruits observed.	Pathologic observations.				Efficacy of control.
					Healthy.	Slightly infected.	Severely infected.	Total loss.	
					Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Calauan, Laguna	Check (tap water)	......	Weekly	22	63.6	18.2	9.1	9.1	....
Do	Lime-sulphur (33° B.)	1:40	do	30	93.3	6.7	Nil.	Nil.	81.6
Do	do	1:40	Biweekly	26	84.6	11.6	3.8	Nil.	57.7
Do	do	1:40	Monthly	21	80.9	19.1	Nil.	Nil.	47.5
Do	do	1:60	Weekly	38	94.7	5.3	Nil.	Nil.	85.4
Do	do	1:80	do	44	93.2	6.8	Nil.	Nil.	81.3
Makar, Cotabato	do	1:70	do	120	96.6	2.6	0.8	Nil.	90.6
Do	Check (not sprayed)	....	do	128	63.8	24.4	10.1	1.7	....

weeks during the blooming period on the first four double rows (56 by 22 by 18 inches), and the latter, on the third four double rows, skipping the middle four double rows as check. In the second series the same spray solutions of weaker concentration were used twice a week, side by side, on a ratoon instead of a plant crop. The Bordeaux mixture applied had the formula 3–2–50, and the lime-sulphur was a 1: 80 dilution. The third series was a repetition of the first in every way except that the strength of the Bordeaux mixture was increased to 3–4–50; the lime-sulphur remained at 1 : 70.

Results.—Upon ripening, all fruits in the experiment were picked separately by the row and cross-cut into slices 1 to 2 centimeters thick for pathologic observations, as shown in Table 2.

Table 2 shows that on the whole Bordeaux mixture is a better spray than lime-sulphur for the control of bacterial fruitlet rots. Spraying three times a week with either seems unnecessarily frequent and causes stunting of the fruits, as revealed by their reduced weights. Of the three strengths of Bordeaux spray tried, the 3–4–50 formula seems best. Another thing to be noted is the general lower efficiency of the whole batch of trials as compared with the results of previous experiments. Such a decrease may be attributable to the difference in the climatic conditions obtaining at the time of the experiments in the respective localities. While there had been practically no rain in Calauan, Laguna Province, and in Makar, Cotabato Province, when the first spraying experiment was in progress, Bukidnon had quite an abundance. The reduced efficiency is attributed to frequent rains, which to some extent wash off the protective covering of the spray, especially when the rain occurs during or soon after spraying.

EXPERIMENT 3

Due to the encouraging results of the preceding preliminary tests, the experimentation was extended to include other kinds of sprays, which were tried out in the pineapple fields of the Philippine Packing Corporation at Santa Fe, Bukidnon Province, in February, 1930.

Materials and methods.—Bordeaux mixture, lime-sulphur, copper sulphate, mercuric chloride, and Semesan were compared in this experiment. Weekly application was made on Hawaiian Smooth Cayenne plants in bloom in field 1 of double rows spaced at 56 by 22 by 18 inches, for a duration of about two

TABLE 2.—*Results of lime-sulphur spray vs. Bordeaux-mixture spray for the control of bacterial fruitlet rots.*

Rows.		Spray solution.	Concentration.	Frequency of application.	Fruits observed.	Average weight.	Pathologic observations.				Efficacy of control.
							Healthy.	Slightly infected.	Severely infected.	Total loss.	
						Kg.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
A	1–4	Bordeaux mixture	3-3-50	Triweekly	1,245	2.13	94.4	5.6	Nil.	Nil.	82.8
A	5–8	Check (not sprayed)			1,440	2.28	67.3	29.6	2.8	0.3	
A	9–12	Lime-sulphur (33° B.)	1:70	Triweekly	1,335	2.10	88.7	11.3	Nil.	Nil.	65.4
B	1–4	Bordeaux mixture	3-2-50	Biweekly	1,490	2.25	95.1	4.9	Nil.	Nil.	70.8
B	5–8	Check (not sprayed)			1,814	2.26	83.2	14.8	1.3	0.7	
B	9–12	Lime-sulphur (33° B.)	1:80	Biweekly	1,586	2.25	94.9	5.1	Nil.	Nil.	69.6
C	1–4	Bordeaux mixture	3-4-50	do.	1,350	2.50	90.3	9.1	0.6	Nil.	79.1
C	5–8	Check (not sprayed)			1,352	2.40	62.2	23.1	11.1	3.6	
C	9–12	Lime-sulphur (33° B.)	1:70	Biweekly	1,293	2.40	84.5	12.4	3.1	Nil.	59.0

months beginning February, 1930. Rows 1 to 3 were sprayed with a 3–4–50 solution of Bordeaux mixture, and rows 4 to 6 with a 4–5–50 solution; rows 7 to 9 were treated with 1 : 70 lime-sulphur (33° Baumé), leaving rows 10 to 12 unsprayed as check. Rows 13 to 15 were sprayed with a 1 : 1,000 solution of copper sulphate, rows 16 to 18 with a 1 : 1,500 solution, and rows 19 to 21 with a 1: 2,000 solution, leaving rows 22 to 24 unsprayed as check. Rows 25 to 27 were sprayed with a 1: 3,000 solution of mercuric chloride, rows 28 to 30 with a 1: 4,000 solution, and rows 31 to 33 with a 1: 5,000 solution, leaving rows 34 to 36 unsprayed as check. Rows 37 to 39 were sprayed with a 1: 200 solution of Semesan, rows 40 to 42 with a 1: 300 solution, and rows 43 to 45 with a 1: 400 solution, leaving rows 46 to 48 unsprayed as check. In every case spraying was done with thoroughness so as to insure uniform and complete covering of the flowers and young fruitlets composing the fruit with the spray material, a condition upon which the efficacy of the treatment greatly depends.

Results.—As soon as signs of ripening were noticed, all fruits in the experiment were picked separately by the row and each individual fruit cross-cut into slices 1 to 2 centimeters thick for pathologic observations. The results of such examinations are shown in Table 3.

Table 3 shows that none of the other sprays tried compare favorably in efficiency with Bordeaux mixture for the control of the bacterial fruitlet rots. It further shows that Bordeaux mixture of the 4–5–50 formula is more effective than the less-concentrated 3–4–50 formula. Because of the stunting effects on the fruits caused by the stronger solution as demonstrated by the reduced weights, such advantage in efficacy over the less-concentrated solution is, nevertheless, dubious and needs further elucidation.

That Bordeaux mixture turned out to be the most effective of the sprays tried may be explained, perhaps, by the fact that it furnishes the best "coating material" in the form of a colloidal precipitate, copper hydroxide [$Cu\ (OH)_2$], which covers the surface of the fruit quite well, protecting it from the pathogens. This colloidal precipitate is said to possess the fungicidal properties of the mixture.

EXPERIMENT 4

Having more or less ascertained that Bordeaux mixture of a concentration between 3–4–50 and 4–5–50 is the best spray tried

TABLE 3.—*Results of weekly spraying with Bordeaux mixture, lime-sulphur, copper sulphate, mercuric chloride, and Semesan, for the control of bacterial fruitlet rots.*

Rows.	Spray solution.	Concentration.	Fruits observed.[a]	Average weight.	Pathologic observations.				Efficacy of control.
					Healthy.	Slightly infected.	Severely infected.	Total loss.	
				Kg.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1–3	Bordeaux mixture	3-4-50	350	2.5	90.3	9.1	0.6	Nil.	79.1
4–6	Do	4-5-50	334	2.2	93.3	6.3	0.4	Nil.	82.3
7–9	Lime sulphur (33° B.)	1:70	293	2.4	84.5	12.4	3.1	Nil.	59.0
10–12	Check (not sprayed)		352	2.4	62.2	23.1	11.1	3.6	
13–15	Copper sulphate	1:1,000	332	2.3	72.0	17.0	8.1	2.9	22.2
16–18	Do	1:1,500	313	2.3	74.9	14.7	8.4	2.0	30.3
19–21	Do	1:2,000	320	2.4	78.8	11.4	9.1	0.7	41.1
22–24	Check (not sprayed)		369	2.4	64.0	17.0	15.3	3.7	
25–27	Mercuric chloride	1:3,000	350	2.2	72.4	16.3	10.2	1.1	38.2
28–30	Do	1:4,000	299	2.2	78.8	11.9	8.0	1.3	52.5
31–33	Do	1:5,000	282	2.4	76.4	11.8	10.6	1.2	47.2
34–36	Check (not sprayed)		238	2.5	55.3	18.2	16.7	9.8	
37–39	Semesan	1:200	212	2.4	70.2	18.2	11.5	0.1	5.1
40–42	Do	1:300	232	2.3	76.4	14.8	8.7	0.6	24.8
43–45	Do	1:400	262	2.4	69.2	16.7	11.6	2.5	1.9
46–48	Check (not sprayed)		216	2.5	68.6	15.0	12.8	3.6	

[a] On account of the prevalence of mealy-bug wilt only about one-third of the plants developed to maturity, hence the small number of fruits observed.

for the control of bacterial fruitlet rots, followed by lime-sulphur (33° Baumé) at 1 : 70 to 1 : 80 dilutions, the next step was to determine the time and frequency of application so as to attain the best results. For this purpose an experiment was undertaken in field 1 of the Philippine Packing Corporation at Santa Fe, Bukidnon Province, in March, 1930.

Materials and methods.—Flowering Smooth Cayenne pineapples grown from Hawaiian plant material were used in this experiment, which consisted of three series. In the first series spraying was done monthly for one, two, three, and four consecutive months, while in the second and third series the application was made fortnightly, also for one, two, three, and four consecutive months. For the first and second series Bordeaux mixture of the formula 3–4–50 was employed during the first month when the fruitlets were still tender and susceptible to scorching; but beginning with the second month when the flowers were already dry, a stronger solution of the formula, 4–5–50, was used till the end. For the third series, fresh lime-sulphur (33° Baumé) at 1 : 80 and 1 : 70 dilution was used. Because of frequent rains in Santa Fe and in Bukidnon Province as a whole, in all cases resin-sal-soda sticker was added to the solution at the rate of 1 : 50. As an additional precaution spraying was done in the morning, for rain usually occurs in the afternoon. Whenever there was rain during the day, spraying was postponed to a later date.

Results.—As soon as signs of ripening were noticed, the fruits were picked separately by the row, then sent to the factory where all the necessary pathologic observations were made. The results are shown in Table 4.

Table 4 shows, first, that of Bordeaux mixture and lime-sulphur the former proved still the better spray for the control of bacterial fruitlet rots; second, that fortnightly application is more effective than monthly application; third, that spraying fortnightly for three to four months from the time the flowers open is necessary to reduce the infections to the minimum, particularly severe infection; fourth, that neither Bordeaux mixture of 4–5–50 formula nor lime-sulphur (33° Baumé) at 1 : 70 dilution cause any scorching or stunting as revealed by the uniform weights of the fruits of both the treated and the control, if applied following the more dilute solutions, or beginning the second month when the flowers have dried up; and lastly, that lime-sulphur is almost as effective as Bordeaux mixture if the spray is

TABLE 4.—*Results of monthly and fortnightly applications of Bordeaux-mixture and lime-sulphur spray for the control of bacterial fruitlet rots.*

Rows.	Spray solution.	Concentration. First month.	Concentration. Last 3 months.	Dates of application.	Fruits observed.	Average weight.	Pathologic observations. Healthy.	Pathologic observations. Slightly infected.	Pathologic observations. Severely infected.	Pathologic observations. Total loss.	Efficacy of control.
				1930		*Kg.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1–3	Bordeaux mixture	3-4-50	4-5-50	Mar. 1	395	2.5	75.0	17.5	6.5	1.0	33.1
4–6	Do.	3-4-50	4-5-50	Mar. 1; Apr. 1	406	2.4	84.5	10.5	4.3	0.7	58.5
7–9	Do.	3-4-50	4-5-50	Mar. 1; Apr. 1; May 1	362	2.5	89.7	7.0	3.3	Nil.	72.4
10–12	Do.	3-4-50	4-5-50	Mar. 1; Apr. 1; May 1; June 1	387	2.4	93.0	4.4	2.6	Nil.	81.3
13–15	Check (not sprayed)				374	2.4	62.6	23.5	11.2	2.7	
16–18	Bordeaux mixture	3-4-50	4-5-50	Mar. 1 and 15	411	2.5	85.0	10.5	4.0	0.5	60.9
19–21	Do.	3-4-50	4-5-50	Mar. 1 and 15; Apr. 1 and 15	423	2.4	90.3	7.0	2.5	0.2	74.7
22–24	Do.	3-4-50	4-5-50	Mar. 1 and 15; Apr. 1 and 15; May 1 and 15.	388	2.4	97.7	2.3	Nil.	Nil.	94.0
25–27	Do.	3-4-50	4-5-50	Mar. 1 and 15; Apr. 1 and 15; May 1 and 15; June 1 and 15.	401	2.5	98.0	2.0	Nil.	Nil.	94.7
28–30	Check (not sprayed)				390	2.4	61.6	24.3	10.3	3.8	
31–33	Lime-sulphur (33° B.)	1:80	1:70	Mar. 1 and 15	398	2.5	84.5	10.7	4.3	0.5	56.3
34–36	Do.	1:80	1:70	Mar. 1 and 15; Apr. 1 and 15	420	2.4	90.2	7.5	2.0	0.3	72.4
37–39	Do.	1:80	1:70	Mar. 1 and 15; Apr. 1 and 15; May 1 and 15.	385	2.5	96.6	3.4	Nil.	Nil.	90.4
40–42	Do.	1:80	1:70	Mar. 1 and 15; Apr. 1 and 15; May 1 and 15; June 1 and 15.	400	2.4	97.0	3.0	Nil.	Nil.	91.5
43–45	Check (not sprayed)				393	2.5	64.5	24.9	8.6	2.0	

obtained from a newly prepared stock solution. Lime-sulphur solution seems to degenerate somewhat with age, as shown by a comparison of the efficiency in Tables 1 and 4 with that in Tables 2 and 3. It should be remembered that the lime-sulphur used for experiments 1 and 4 was obtained from a newly prepared stock solution, while that employed for experiments 2 and 3 was made from an old stock solution. This finding confirms the traditional view that nothing but freshly prepared spray solution should be used, if the highest efficacy of control is desired. This is especially true of Bordeaux mixture. Rightly mixed and freshly made, Bordeaux mixture is remarkably adhesive and does not yield easily to the washing action of rains.

SHADING

As the temperature requirements of the causal bacteria are rather high,(14, 15) it was assumed that shading the fruits from the direct heat of the sun might help to minimize the ravages resulting from bacterial fruitlet rots.

EXPERIMENT 5

At the suggestion of Mr. H. A. White, president of the Philippine Packing Corporation, a shading experiment was carried out at Calauan, Laguna Province, in January, 1927, for the purpose of determining the possible adverse effect of shading on the incidence and development of the infection.

Materials and methods.—Just before the flowering season commenced, two bamboo frames about 60 meters long, 3 meters wide, and 2 meters high were erected over a plot consisting of fourteen rows of sixty Smooth Cayenne plants each, spaced 1 meter by 1 meter each way, the first frame covering rows 3 to 5 and the second, rows 10 to 12. On top of each of the frames dry coco-palm leaves were placed crosswise in such a way as to furnish more or less uniform shading throughout, as shown in Plate 1, fig. 2.

Results.—The fruits, when ripe, were picked by the row and those of rows 1, 7, 8, and 14 grouped together as unshaded fruits; those of rows 3, 5, 10, and 12 as partially shaded fruits; those of rows 4 and 11 as well-shaded fruits. Those of rows 2, 6, 9, and 13 were discarded as undesirable. The fruits were then brought to the laboratory at the Bureau of Science in Manila for pathologic examination and other necessary pertinent data as shown in Tables 5 and 6.

TABLE 5.—*Adverse effects of shading on bacterial fruitlet rots.*

Treatment.	Fruits observed.	Pathologic observations.				Efficacy of control.
		Healthy.	Slightly infected.	Severely infected.	Total loss.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Unshaded	108	66.7	21.9	9.8	1.6	....
Partially shaded	114	71.2	22.6	5.4	0.8	13.5
Well shaded	59	76.2	18.7	5.1	Nil.	28.5

It is shown in Table 5 that shading reduces the damage caused by the bacterial fruitlet rots, the beneficial effect being evident not so much in the decrease of the total percentage of infection as in the increased percentage of fruits good for canning. It would seem that shading does not prevent bacterial fruitlet-rot infections, but it creates a condition rather unfavorable for their progress.

To determine what that condition is, separate samples of both the exposed and the shaded fruits were submitted to the organic chemistry division of the Bureau of Science for analysis; then a comparison was made between the daily temperature of the exposed and the shaded fruits on the one hand, and the daily temperature of the exposed atmosphere and shaded atmosphere on the other. The procedure was as follows: A mercury thermometer was thrust 15 centimeters deep into each of two mature Smooth Cayenne fruits, one exposed and the other shaded; a third thermometer was suspended in the air 75 centimeters above the soil near the exposed fruit; the readings of each thermometer were taken every two hours from 6 a. m. to 6 p. m. for three months; the fourth, which is a self-recording hygrothermograph, was placed under a shed with free circulation of air. The results are shown in Table 6 and in text fig. 1.

TABLE 6.—*Comparative analyses of exposed fruits and shaded fruits.*

Fruits.	Brix of juice corrected to 27.5°C.	pH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Exposed	14.39	4.37	0.39	7.82	3.97	12.19
Shaded	14.40	4.37	0.40	7.66	4.31	12.37

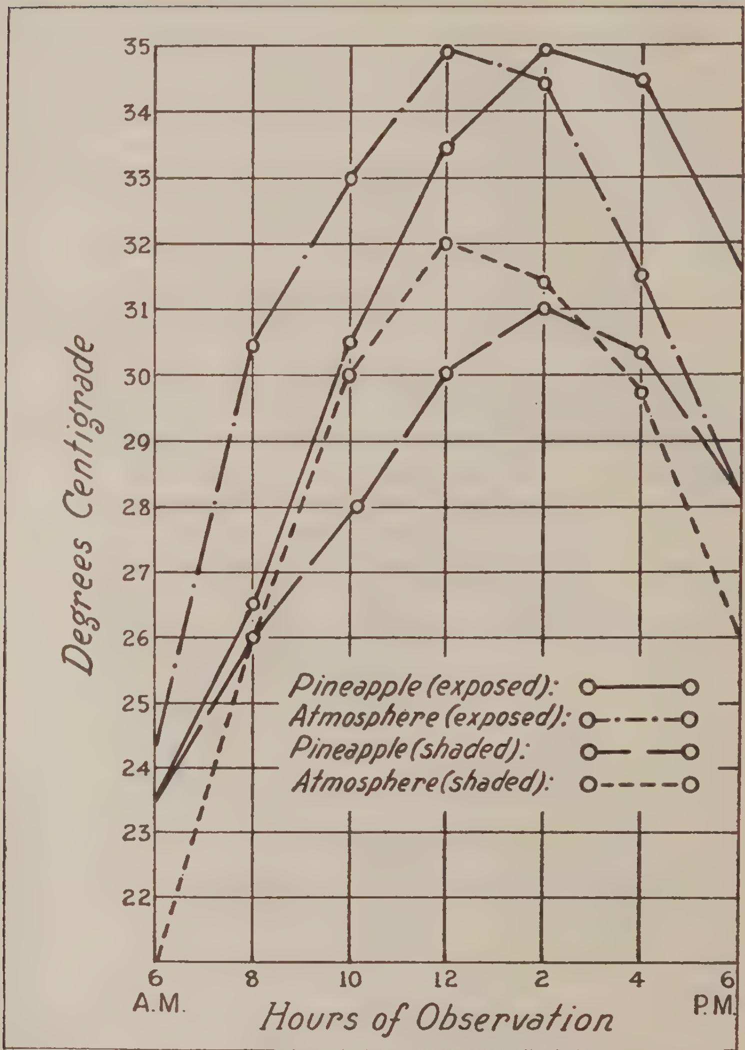

FIG. 1. Showing temperature relations from 6 a. m. to 6 p. m. between atmosphere and pineapple, both shaded and exposed.

Table 6 shows that shading has not changed the composition of the fruits so much as materially to affect the activities of the bacterial pathogens responsible for the fruitlet rots one way or another. On the other hand text fig. 1 shows that the tem-

perature of the exposed air is about 3° C. higher than that of the shaded air, and that the temperature of the exposed fruit is correspondingly higher by about 4° C. than that of the shaded fruit. In view of the fact that both *Erwinia ananas* Serrano (14) and *Phytomonas ananas* Serrano, (15) causing the pineapple fruitlet rots, require a fairly high temperature for optimum growth, the low average atmospheric temperature under shade which necessarily lowers the temperature of the shaded fruits, may well explain the marked reduction in the severity of the bacterial fruitlet rots among the shaded pineapple fruits, and also the observations of pineapple growers that fruit-rot infections are worst following protracted hot weather.

EXPERIMENT 6

Because of the encouraging results obtained from the preliminary experiments on shading, further trials were carried out with different types of sheds. Experiment 6 was performed in May, 1930, in field 1 of the Philippine Packing Corporation at Santa Fe, Bukidnon Province.

Materials and methods.—The experimental block with Smooth Cayenne fruits adjudged to mature in two to three months was divided into five sections of ten double rows each. The first five rows of each of three sections were shaded with cogon grass [*Imperata cylindrica* (Linn.) Beauv.] in three different ways; first, by putting a cogon-grass ring closely around the fruit; second, by spreading a cogon-grass bundle top down over the fruit; third, by spreading a cogon-grass layer over the fruit, leaving every second five rows unshaded as check. The fourth section was shaded by placing a bagokbok-grass ring (*Apluda mutica* Linn.) around each fruit of the first five rows, while the fifth was shaded by tying the pineapple leaves together over the fruits of the first five rows, leaving the fruits of the intervening ten rows unshaded as check. At harvest the fruits were grouped according to type of shading, and sent to the factory where the necessary observations were made. The results are shown in Table 7.

About two to three weeks prior to the ripening of the fruits a comparison of the relative temperatures of the fruits under the last four treatments was made by thrusting one mercury thermometer 15 centimeter deep into each of two fruits under each treatment, one on the side facing east and the other on the side facing west, taking the readings every day at 6 a. m., 12 noon, and 6 p. m., for a week. The results are included in Table 7.

TABLE 7.—*The effect of shading on the prevalence of bacterial fruitlet rots and on the color of the fruits.*

Type of shading.	Temperature of the fruits.	Fruits observed.	Pathologic observations.			
			Healthy.	Slightly infected.	Severely infected.	Total loss.
	°F.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cogon ring	----------	669	83.9	12.2	3.2	0.7
Cogon bundle	----------	629	87.3	10.4	1.7	0.6
Cogon layer	77.3	1,166	88.2	10.2	1.5	0.1
Bagokbok ring	77.1	1,354	90.3	8.0	1.7	Nil.
Tying leaves	79.0	854	84.6	13.2	1.9	0.3
Check	79.6	1,127	72.2	23.7	3.8	0.8

Type of shading.	Color of pulp.		Efficacy of control.
	Yellow.	White.	
	Per cent.	*Per cent.*	*Per cent.*
Cogon ring	51.1	48.9	42.1
Cogon bundle	40.5	59.5	54.3
Cogon layer	29.7	70.3	57.5
Bagokbok ring	38.1	61.9	65.1
Tying leaves	51.9	48.1	44.6
Check	52.2	47.8	----------

Table 7 shows that of the different types of shading tried the bagokbok ring gave the highest efficacy of control, or 65.1 per cent, followed by the cogon layer, with 57.5 per cent. These high efficacy ratings are associated with correspondingly high reduction in daily fruit temperature, indicating the adverse effect of low temperature on the pathogens. This result is not entirely satisfactory, however. In the first place, it is about 30 per cent less than the efficacy of either Bordeaux-mixture spray or lime-sulphur spray; and in the second place, shading seems to cause discoloration of the fruits, reducing the number of fruits with yellow pulp by about 10 per cent. This effect is the reverse of that of spraying which, according to actual observation, improves the color of the fruits treated. Therefore, for the control of the bacterial fruitlet rots shading has proved to be inferior to spraying.

FERTILIZER APPLICATION

As early as 1863 crop investigators found that oftentimes the application of fertilizer resulted in either decreasing or aggravating the diseases of plants. In order to determine what effects,

if any, fertilizer application would have on the prevalence of the pineapple bacterial fruitlet rots under Bukidnon conditions, the following experiment was conducted.

EXPERIMENT 7

Experiment 7 was begun July 1, 1929, in field 1 of the Philippine Packing Corporation, in Bukidnon, which was planted in January of the same year to Smooth Cayenne planting material imported from Hawaii.

Materials and methods.—The block chosen for this trial was the best in the whole Hawaiian Smooth Cayenne field, although the stand was not as uniform as could have been desired, owing to the presence of mealy-bug wilt, which required several replantings. Six chemical fertilizers were tried, and each was applied in three different amounts per hectare, in one, two, and three replenishments at quarterly intervals. The fertilizer was strewn by hand over the bases of the plants along both sides of the row, and then covered by hoeing the dirt in. Every other three rows were left untreated, the interjacent remaining as check and the two adjacent as blanket rows. The planting plan of the entire experiment is given in Table 8.

TABLE 8.—*The arrangement of fertilizer-plot experiment.*

[N, Ammonium sulphate, 20.4 per cent; P, superphosphate (acid phosphate) 20.4 per cent; K, potassium sulphate, 49.6 per cent; NP, Ammo-Phos, 20–20; NPK, Corona No. 1, 10–6–2; N-P-K, Filfer, 17–10–3.5.]

Row.	Treatment.	Months of application.	Row.	Treatment.	Months of application.
	Kg. per ha.			*Kg. per ha.*	
1	N, 500	7th, 10th, and 13th.	19	N, 500	7th and 13th.
2	N, 1,000	Do.	20	N, 1,000	Do.
3	N, 1,500	Do.	21	N, 1,500	Do.
4	Blanket		22	Blanket	
5	Check		23	Check	
6	Blanket		24	Blanket	
7	N, 500	7th and 10th.	25	N, 500	7th.
8	N, 1,000	Do.	26	N, 1,000	Do.
9	N, 1,500	Do.	27	N, 1,500	Do.
10	Blanket		28	Blanket	
11	Check		29	Check	
12	Blanket		30	Blanket	
13	N, 500	10th and 13th.	31	N, 500	10th.
14	N, 1,000	Do.	32	N, 1,000	Do.
15	N, 1,500	Do.	33	N, 1,500	Do.
16	Blanket		34	Blanket	
17	Check		35	Check	
18	Blanket		36	Blanket	

TABLE 8.—*The arrangement of fertilizer-plot experiment*—Continued.

[N, Ammonium sulphate, 20.4 per cent; P, superphosphate (acid phosphate) 20.4 per cent; K, potassium sulphate, 49.6 per cent; NP, Ammo-Phos, 20–20; NPK, Corona No. 1, 10–6–2; N-P-K, Filfer, 17–10–3.5.]

Row.	Treatment.	Months of application.	Row.	Treatment.	Months of application.
	Kg. per ha.			*Kg. per ha.*	
37	N, 500	13th.	85	K, 200	7th, 10th, and 13th.
38	N, 1,000	Do.	86	K, 500	Do.
39	N, 1,500	Do.	87	K, 1,000	Do.
40	Blanket		88	Blanket	
41	Check		89	Check	
42	Blanket		90	Blanket	
43	P, 500	7th, 10th, and 13th.	91	K, 200	7th and 10th.
44	P, 1,000	Do.	92	K, 500	Do.
45	P, 1,500	Do.	93	K, 1,000	Do.
46	Blanket		94	Blanket	
47	Check		95	Check	
48	Blanket		96	Blanket	
49	P, 500	7th and 10th.	97	K, 200	10th and 13th.
50	P, 1,000	Do.	98	K, 500	Do.
51	P, 1,500	Do.	99	K, 1,000	Do.
52	Blanket		100	Blanket	
53	Check		101	Check	
54	Blanket		102	Blanket	
55	P, 500	10th and 13th.	103	K, 200	7th and 13th.
56	P, 1,000	Do.	104	K, 500	Do.
57	P, 1,500	Do.	105	K, 1,000	Do.
58	Blanket		106	Blanket	
59	Check		107	Check	
60	Blanket		108	Blanket	
61	P, 500	7th and 13th.	109	K, 200	7th.
62	P, 1,000	Do.	110	K, 500	Do.
63	P, 1,500	Do.	111	K, 1,000	Do.
64	Blanket		112	Blanket	
65	Check		113	Check	
66	Blanket		114	Blanket	
67	P, 500	7th.	115	K, 200	10th.
68	P, 1,000	Do.	116	K, 500	Do.
69	P, 1,500	Do.	117	K, 1,000	Do.
70	Blanket		118	Blanket	
71	Check		119	Check	
72	Blanket		120	Blanket	
73	P, 500	10th.	121	K, 200	13th.
74	P, 1,000	Do.	122	K, 500	Do.
75	P, 1,500	Do.	123	K, 1,000	Do.
76	Blanket		124	Blanket	
77	Check		125	Check	
78	Blanket		126	Blanket	
79	P, 500	13th.	127	NP, 500	7th, 10th, and 13th.
80	P, 1,000	Do.	128	NP, 1,000	Do.
81	P, 1,500	Do.	129	NP, 1,500	Do.
82	Blanket		130	Blanket	
83	Check		131	Check	
84	Blanket		132	Blanket	

TABLE 8.—*The arrangement of fertilizer-plot experiment*—Continued.

[N, Ammonium sulphate, 20.4 per cent; P, superphosphate (acid phosphate) 20.4 per cent; K, potassium sulphate, 49.6 per cent; NP, Ammo-Phos, 20–20; NPK, Corona No. 1, 10–6–2; N-P-K, Filfer, 17–10–3.5.]

Row.	Treatment.	Months of application.	Row.	Treatment.	Months of application.
	Kg. per ha.			*Kg. per ha.*	
133	NP, 500	7th and 10th.	181	NPK, 500	10th and 13th.
134	NP, 1,000	Do.	182	NPK, 1,000	Do.
135	NP, 1,500	Do.	183	NPK, 1,500	Do.
136	Blanket		184	Blanket	
137	Check		185	Check	
138	Blanket		186	Blanket	
139	NP, 500	10th and 13th.	187	NPK, 500	7th and 13th.
140	NP, 1,000	Do.	188	NPK, 1,000	Do.
141	NP, 1,500	Do.	189	NPK, 1,500	Do.
142	Blanket		190	Blanket	
143	Check		191	Check	
144	Blanket		192	Blanket	
145	NP, 500	7th and 13th.	193	NPK, 500	7th.
146	NP, 1,000	Do.	194	NPK, 1,000	Do.
147	NP, 1,500	Do.	195	NPK, 1,500	Do.
148	Blanket		196	Blanket	
149	Check		197	Check	
150	Blanket		198	Blanket	
151	NP, 500	7th.	199	NPK, 500	10th.
152	NP, 1,000	Do.	200	NPK, 1,000	Do.
153	NP, 1,500	Do.	201	NPK, 1,500	Do.
154	Blanket		202	Blanket	
155	Check		203	Check	
156	Blanket		204	Blanket	
157	NP, 500	10th.	205	NPK, 500	13th.
158	NP, 1,000	Do.	206	NPK, 1,000	Do.
159	NP, 1,500	Do.	207	NPK, 1,500	Do.
160	Blanket		208	Blanket	
161	Check		209	Check	
162	Blanket		210	Blanket	
163	NP, 500	13th.	211	N-P-K, 500	7th, 10th, and 13th.
164	NP, 1,000	Do.	212	N-P-K, 1,000	Do.
165	NP, 1,500	Do.	213	N-P-K, 1,500	Do.
166	Blanket		214	Blanket	
167	Check		215	Check	
168	Blanket		216	Blanket	
169	NPK, 500	7th, 10th, and 13th.	217	N-P-K, 500	7th and 10th.
170	NPK, 1,000	Do.	218	N-P-K, 1,000	Do.
171	NPK, 1,500	Do.	219	N-P-K, 1,500	Do.
172	Blanket		220	Blanket	
173	Check		221	Check	
174	Blanket		222	Blanket	
175	NPK, 500	7th and 10th.	223	N-P-K, 500	10th and 13th.
176	NPK, 1,000	Do.	224	N-P-K, 1,000	Do.
177	NPK, 1,500	Do.	225	N-P-K, 1,500	Do.
178	Blanket		226	Blanket	
179	Check		227	Check	
180	Blanket		228	Blanket	

TABLE 8.—*The arrangement of fertilizer-plot experiment*—Continued.

[N, Ammonium sulphate, 20.4 per cent; P, superphosphate, (acid phosphate) 20.4 per cent; K, potassium sulphate, 49.6 per cent; NP, Ammo-Phos, 20–20; NPK, Corona No. 1, 10–6–2; N-P-K, Filfer, 17–10–3.5.]

Row.	Treatment.	Months of application.	Row.	Treatment.	Months of application.
	Kg. per ha.			*Kg. per ha.*	
229	N-P-K, 500	7th and 13th.	241	N-P-K, 500	10th.
230	N-P-K, 1,000	Do.	242	N-P-K, 1,000	Do.
231	N-P-K, 1,500	Do.	243	N-P-K, 1,500	Do.
232	Blanket		244	Blanket	
233	Check		245	Check	
234	Blanket		246	Blanket	
235	N-P-K, 500	7th.	247	N-P-K, 500	13th.
236	N-P-K, 1,000	Do.	248	N-P-K, 1,000	Do.
237	N-P-K, 1,500	Do.	249	N-P-K, 1,500	Do.
238	Blanket		250	Blanket	
239	Check		251	Check	
240	Blanket		252	Blanket	

Results.—All fruits, upon ripening, were picked by the row, weighed, and taken to the factory for the necessary observations, such as acidity in terms of pH value, pathologic infections, and color of pulp; the results are shown in Table 9. Every fertilizer used is represented in this table only by the row giving the best results in so far as increasing the tonnage production and reducing the bacterial fruitlet-rot infections are concerned.

Table 9 shows, first of all, a 0.2-kilo increase in the average weight per fruit of row 32, fertilized once with ammonium sulphate at the rate of 1,000 kilos per hectare the tenth month; of row 98, fertilized with potassium sulphate at the rate of 500 kilos per hectare, in two equal replenishments the tenth and thirteenth months; of row 141, fertilized with Ammo-Phos at the rate of 1,500 kilos per hectare, in two equal replenishments the tenth and thirteenth months; of row 183, fertilized with Corona No. 1 at the rate of 1,500 kilos per hectare, in two equal replenishments the tenth and thirteenth months; and of row 224, fertilized with Filfer at the rate of 1,000 kilos per hectare, also in two equal replenishments the tenth and thirteenth months. It seems quite evident that under the conditions obtaining in field 1, Santa Fe, Bukidnon Province, fertilizer application with ammonium sulphate, potassium sulphate, or any other complete fertilizer at the rate given above would be most beneficial to Smooth Cayenne when applied in two equal replenishments during the tenth and thirteenth months. This would seem to indicate that the bulk of the essential elements

TABLE 9.—*The effects of fertilizers on Smooth Cayenne fruits with special reference to the prevalence of bacterial fruitlet-rot infections.*

Row.	Fertilizer.	Composition.			Rate of application.	Fruits observed.	Average weight.	Color of pulp.	
		N	P_2O_5	K_2O				Yellow.	White.
					Kg. per ha.		*Kg.*	*Per cent.*	*Per cent.*
32	Ammonium sulphate	20.6	0	0	1,000	308	2.4	60.5	39.5
49	Phosphate, acid	0	20.4	0	500	274	2.2	66.7	33.3
98	Potassium sulphate	0	0	49.6	500	306	2.4	65.0	35.0
141	Ammo-Phos	20.0	20.0	0	1,500	280	2.4	74.2	25.8
183	Corona No. 1	10.0	6.0	2.0	1,500	292	2.4	67.7	32.3
224	Filler	17.0	10.0	3.5	1,000	318	2.4	73.9	26.1
[b]	Checks (not fertilized)	0	0	0	0	297	2.2	52.2	47.8

Row.	Fertilizer.	pH value[a] (acidity).		Pathologic observations.				Efficacy of control.
		Healthy.	Diseased.	Healthy.	Slightly infected.	Severely infected.	Total loss.	
				Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
32	Ammonium sulphate	3.9	4.4	79.9	12.0	6.3	1.8	6.5
49	Phosphate, acid	3.9	4.8	80.4	15.7	3.7	0.2	8.8
98	Potassium sulphate	3.8	4.3	94.5	5.4	0.1	Nil.	74.4
141	Ammo-Phos	3.9	4.5	81.6	12.8	5.3	0.3	14.4
183	Corona No. 1	3.8	4.3	90.6	8.4	0.9	0.1	56.2
224	Filler	3.9	4.2	83.9	9.3	6.4	0.4	25.1
[b]	Checks (not fertilized)	4.0	4.5	78.5	16.6	4.7	0.2	

[a] The pH values were determined by colorimetric method with La Motte's apparatus. Each composite sample was prepared by extracting separately fresh juice of ten uniform ripe fruits, either healthy or diseased.

[b] Rows 35, 58, 101, 143, 185, and 227 are the checks.

for pineapple-fruit development are most needed after the plants have fully developed vegetatively and are ready for the elaborate transformation incidental to sexual development.

Table 9 further shows that treatment with any one of the commercial fertilizers tried improves the color of the fruit pulp, increasing the number of rich yellow fruits from about 6 to 26 per cent.

Of all the benefits derived from the fertilizer treatments, disease control as demonstrated by potassium sulphate is, perhaps, the most important, at least from the standpoint of the plant pathologist. Potash application in the form of potassium sulphate caused a reduction in total infection by about 75 per cent, at the same time rendering the treated fruits all good for canning. These positive results seem to confirm the reports of Marchal,(8) Spinks,(17) Russell,(13) Finlow,(4) and Butler,(2) to the effect that potash application minimizes the incidence of plant diseases. On the other hand, ammonium sulphate increased the number of fruits unfit for canning or severely infected, by more than 3 per cent, and caused no appreciable reduction in the total infections, while phosphorus in the form of acid phosphate showed very little beneficial effect. As was to be expected, a combination of ammonium sulphate and acid phosphate showed a better result than ammonium sulphate alone. It appears, therefore, that the reduced amount of infection obtained from the treatment with Corona No. 1 and with Filfer were mainly due to the potash content of these fertilizers. It may be deduced further that Corona No. 1 showed superiority over Filfer in effecting a partial control of bacterial fruitlet rots, because of the fact that Filfer contains almost twice as much nitrogen as Corona No. 1, and nitrogen is a fertilizer ingredient that Sheldon,(16) Peltier,(11) Liebig,(6) Roberts,(12) Laurent,(5) Marchal,(8) Delacroix,(3) McAlpine,(9) Spinks,(17) McCue and Pelton,(10) Butler,(2) and Thomas,(18) found to be a predisposing cause of plant diseases, or to favor their occurrence, on the assumption that the succulence of the tissues caused by it facilitates parasitic invasion.

How potash and to some extent phosphorus increased the resistance of pineapple fruits to bacterial fruitlet-rot infections is not clearly known. It would seem that the increased acidity of the fruits treated singly with potassium sulphate (pH 3.8) and in combination with other fertilizing ingredients (pH 3.9), and

those treated with other fertilizers minus potash (pH 3.9) over the check (pH 4), is due to the inhibitive influence of the acid. In accordance with, and in support of, this view are the results obtained by the writer (14,15) from the cultural studies made on the acid requirements of the bacterial fruitlet-rot pathogens, showing that an acidity of pH 3.8 is almost prohibitive for their growth. This is perchance the reason why in Hawaii, where the acidity of pineapple fruits ranges from pH 3.6 to pH 3.8, the bacterial fruitlet-rot diseases are very mild. These findings would seem to find further support in the reports of earlier investigators like Delacroix,(3) who suggested that phosphate inhibits disease by increasing the acidity of cell sap; Bishop,(1) and Tracy,(19) who stated that potash application increases the acidity of tomato fruits; Truog,(20) and Truog and Meacham,(21) who, in interpreting the results of their experiments, advanced the opinion that the acidity of the plant sap can be modified by the acidity of the soil. There is, therefore, a strong indication that the relative acidity of the fruit is a controlling factor in the incidence and seriousness of bacterial fruitlet rots of pineapple.

Another factor, which perhaps contributed disease resistance to the pineapple fruits treated with potash, is the firmness of the tissues resulting from the treatment. It had been observed that fruits from the potash-treated lots were firmer and less succulent than the control, and particularly so compared with those treated with ammonium sulphate and Ammo-Phos. It would appear, therefore, that the firmer and the less succulent the fruits are, the less susceptible they become to parasitic invasions.

BREEDING AND SELECTION FOR IMMUNITY

Just as breeding and selection of the most desirable plants for seed are essential to increase yield, so also are breeding and selection for resistance or immunity to control plant diseases and pests. The genetics department of the Experiment Station of the Association of Hawaiian Pineapple Canners has recently produced a pineapple hybrid, by crossing Smooth Cayenne with a Brazilian wild pineapple, possessed of great vigor of plant and root growth, nematode resistance, high-sugar and high-acid content. In the light of these findings the results obtained from the following preliminary experiments become quite significant.

EXPERIMENT 8: MASS SELECTION I

The writer (14, 15) has reported that approximately 22 to 27 per cent of the pineapple fruits in his experiments were not infected at all, even after they had been sprayed heavily with water suspension of the bacterial pathogens during their development. In view of this phenomenon mass selection of apparently resistant plants was considered full of promise in at least minimizing the ravages of the infections, and an experiment to determine the possibilities of such a method was undertaken beginning the middle of 1928.

Materials and methods.—Two thousand one hundred fruited Smooth Cayenne plants in the trial plots belonging to the Philippine Packing Corporation at Santa Fe, Bukidnon Province, were numbered consecutively from 1 to 2,100 in quadruplicates, the first two numbers being placed on each of two leaflets of the crown and the other two on each of two conspicuous leaves of the plant. To make sure that a representative group was covered, plants with fruits of varied sizes and stages of development were selected. As soon as signs of ripening were noticed the fruits were picked and each cross-cut into slices 1 to 2 centimeters thick for bacterial fruitlet-rot observation; crowns of infected fruits were placed in one pile and crowns of healthy fruits in another. The corresponding slips and suckers were gathered with care and separated likewise. After proper curing and trimming they were planted separately in two general groups as "healthy stock" and "diseased stock" and arranged in rows of suckers, slips, and crowns, at a standard spacing of 56 by 22 by 18 inches (approximately 1.39 by 0.56 by 0.46 meter).

Results.—About the middle of 1929 the ratoon crop of the numbered plants was picked and, following the data on first plant crop observations, grouped as "healthy stock" and "diseased stock," and each fruit cross-cut later into slices 1 to 2 centimeters thick and examined for bacterial fruitlet-rot infection. In the following year (1930) the plant crops of both healthy stock and diseased stock were picked by the group as they ripened, and the necessary pathologic observations made as before. All pertinent data gathered from the beginning of the experiment are shown in text fig. 2, together with pathologic observations on fruits from unselected plants maturing at the same time, as check.

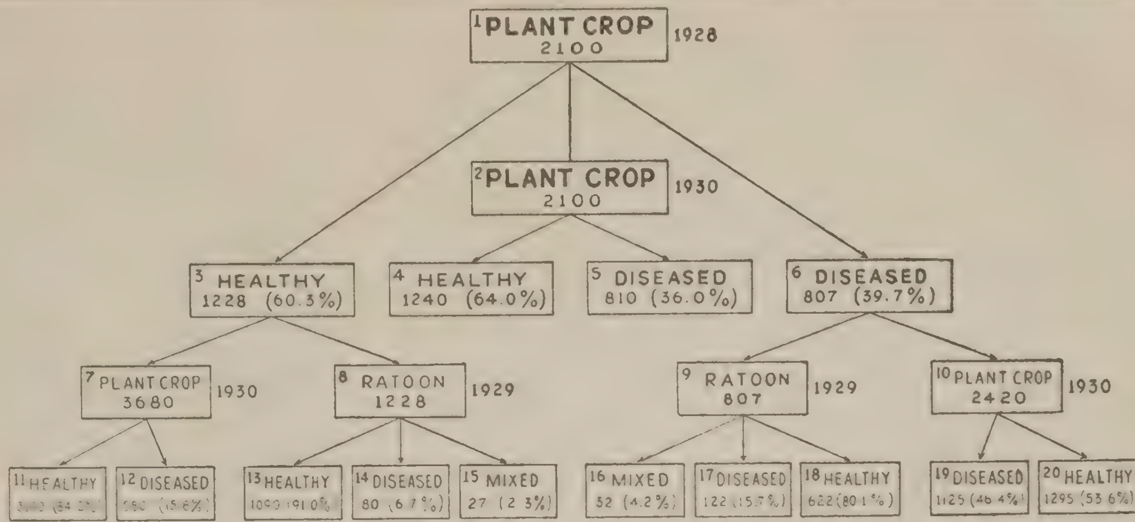

FIGURE 2. *Diagram showing possible beneficial effect of plant selection in reducing bacterial fruitlet rot infections.*
LEGENDS: *1 = plant crop, unselected; 2 = same as 1; 3 = part of 1, with healthy fruits; 4 = part of 2, with healthy fruits; 5 = part of 2, with diseased fruits; 6 = part of 1, with diseased fruits, 7 = plant crop of 3; 8 = ratoon of 3; 9 = ratoon of 6; 10 = plant crop of 6; 11 = part of 7, with healthy fruits; 12 = part of 7, with diseased fruits; 13 = part of 8, with healthy fruits; 14 = part of 8, with diseased fruits; 15 = part of 8, with some healthy and some diseased fruits; 16 = part of 9, with some healthy and some diseased fruits; 17 = part of 9, with diseased fruits; 18 = part of 9, with healthy fruits; 19 = part of 10, with diseased fruits; 20 = part of 10, with healthy fruits.*

FIG. 2. Showing possible beneficial effects of plant selection.

Text fig. 2 shows, first, that of the 2,100 fruits tagged only 2,035 were accounted for at harvest owing to mortality due to mealy-bug wilt. Of this number 1,228, or 60.3 per cent, were free from bacterial fruitlet-rot infection, while 807, or 39.7 per cent, were infected; second, that the plant crop of the healthy group had about 31 per cent more healthy fruits than the plant crop of the diseased group, and about 20 per cent more than the plant crop of the unselected group, for the same year (1930); third, that the ratoon of the healthy group had about 11 per cent more healthy fruits than the ratoon of the diseased group; fourth, that the ratoons of both groups had higher percentages of healthy fruits than their respective plant crops; and fifth, that some ratoon plants of either group produced one or two healthy fruits simultaneously with one or two diseased fruits.

These results, although too meager to show anything definite and conclusive, indicate that some strains of the Smooth Cayenne variety are quite resistant to bacterial fruitlet-rots while others are extremely susceptible. It seems possible, therefore, that continuous selection for several years may bring about highly resistant strains that will check the ravages caused by the disease. That ratoon crops are less susceptible to infections than plant crops is to be expected, because ratoon fruits have proved to be less succulent but more acid than plant crop fruits. Quicker and better results may, perhaps, be obtained from this type of selection by spraying the fruits during their development with water suspension of the bacterial pathogens instead of leaving them to casual infections, because in this way only the highly resistant or immune plants, if any, will remain uninfected.

EXPERIMENT 9: MASS SELECTION II

Field observations have shown great variability of the agronomic characters of Smooth Cayenne plants; for example, in the shape and size of fruits grown under apparently identical conditions, in the number of suckers and slips and their positions relative to the fruit, in the opening of the "eyes" or position of the flower bracts at maturity, etc. While such variations may largely be nothing more nor less than the variations within a pure line, it is possible also to find somatic mutations among them. It is likewise possible for such mutants to possess high resistance to, or immunity from, infection, in addition to other important economic characteristics. In order, therefore, to find out the significance of such variations, and to determine whether

or not any correlation exists between certain specific characters of an individual plant and its resistance to, or immunity from, infections, an experiment was conducted, beginning the latter part of 1928, in Santa Fe, Bukidnon Province. This experiment differs from the preceding one in that initial selection was based on the agronomic features of the plants. It should, however, eventually check up the results of the preceding experiment.

Materials and methods.—Smooth Cayenne plants with fruits just maturing and showing agronomic characteristics that made them quite distinct from one another were used. The five most prominent and apparently distinct types described below were selected and numbered 1, 2, 3, 4, and 5, respectively. Numbering was done as in the first selection test, so as to insure the identity of each fruit with its respective crown, slips, suckers, etc., which were to be used for further trials.

Type 1.—Most conspicuous because of its exceptionally large size and rareness; leaves purplish green, proportionally larger and more widely spread than those of other types; produces one or two suckers, rarely three, with usually the same number of shoots as fruit becomes half-developed, but no slips; fruits extraordinarily large, tapering, with small, rather stubby, purplish crown, erect or inclined to one side.

Type 2.—Neither as robust nor as conspicuous as type 1; leaves green with light purplish tint; produces one or two suckers, the same number of shoots, and two or more hapas, but no slips; fruits comparatively smaller than in type 1, cylindrical, usually with smaller eyes, and decidedly inclined to one side at maturity, but with a green crown larger than in type 1.

Type 3.—The same as type 2 except that the fruit is erect even at maturity, owing to ample support provided by a more or less uniform circular distribution of shoots and hapas.

Type 4.—Medium-sized plants with medium-sized green leaves and medium-sized cylindrical, rather large-eyed fruits; produces one or two suckers and five or more slips, but no shoots and no hapas; crown fairly large and well developed.

Type 5.—Essentially the same as type 4 except that the eyes are not as large and more or less tightly closed even during the flowering period.

Results.—As soon as signs of ripening were noticed, the fruits were picked, grouped into their respective types, and taken to the laboratory for the necessary observations, as shown in Table 10.

TABLE 10.—*Reactions of different strains of Smooth Cayenne fruits to bacterial fruitlet-rot infections.*

Type.	Fruits observed.	Average weight.	Pathologic observations.					Color of pulp.	
			Healthy.	Slightly infected.	Severely infected.	Total loss.	Total infection.	Yellow.	White.
		Kg.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	856	3.5	82.0	10.3	7.7	Nil.	18.0	90.1	9.9
2	199	2.8	79.4	13.0	7.1	0.5	20.6	79.5	20.5
3	456	2.8	89.9	10.1	Nil.	Nil.	10.1	67.5	32.5
4	223	2.0	74.8	21.5	2.4	1.3	24.2	63.2	36.8
5	630	2.0	88.4	9.2	2.4	Nil.	11.6	69.7	30.3

Table 10 shows that the total bacterial fruitlet-rot infections found on the different types examined are 18 per cent for type 1, of which 10.3 per cent were slightly infected and 7.7 per cent were severely infected; 20.6 per cent for type 2, of which 13 per cent were slightly infected, 7.1 per cent were severely infected, and 0.5 per cent was a total loss; 10.1 per cent for type 3, all slightly infected; 25.2 per cent for type 4, of which 21.5 per cent wère slightly infected, 2.4 per cent were severely infected, and 1.3 per cent were a total loss; and 11.6 per cent for type 5, of which 9.2 per cent were slightly infected and 2.4 per cent were severely infected. It is quite evident from these results that type 3 possesses the highest degree of resistance to the infection, followed closely by type 5. Type 1 seems to represent the mean, and types 2 and 4, the highly susceptible strains. In weight of fruit and richness in color of pulp, the latter one of the factors in grading fruits for canning, type 1 seems to possess ample margin to lead.

Just what particular characters of types 3 and 5 give them a high degree of resistance to infection is not definitely understood. It seems possible, however, that in the case of type 3 the hapas and shoots surrounding the fruit serve as a blanket, partially protecting the fruit from intimate contact with the bacterial pathogens; or, perhaps, the shade furnished by the surrounding hapas and shoots causes enough cooling greatly to lessen the activities of the invading bacterial pathogens. In the case of type 5 perhaps the tightness of the bracts covering the eyes prevents the bacterial parasites, to a large extend, from entering the eye bowl, whence they enter the placental lobes of the fruitlets.

It is not known whether or not any one or all of these five types will breed true, inasmuch as the results of the plantings made from their planting materials are not available and the work has not been carried on over a sufficient length of time to justify any conclusion. These data are here presented for the purpose of suggesting the possibility of finding among the different Cayenne strains a mutant possessing important economic characters as well as a high degree of resistance to fruitlet-rot infections. Should mass selection fail to accomplish the desired end, another method of attack that might serve the same purpose would be hybridization and pedigree selection.

SUMMARY

1. The bacterial fruitlet-rots of the pineapple in the Philippines are so serious and destructive as to endanger the future of the industry unless effective means of control are adopted.

2. There are at least four factors favoring the maladies; namely, incomplete closing of the eyes, fewness of shoots, high temperature, and low acidity of the fruit.

3. Elimination of these factors, particularly low acidity of the fruit, will greatly minimize the ravages caused by fruitlet-rots. Incomplete closing of the eyes and fewness of shoots may, perhaps, be remedied by breeding and selection. The bad effects of high temperature may be partly overcome by shading or by growing the pineapples on high land; for example, at about 2,000 feet above sea level. The low acidity of the fruit may be corrected either by breeding and selection, by the proper application of suitable fertilizers, or proper soil treatment that will endow the soil with a percentage of acidity that is high enough to render the fruits resistant to fruitlet rot without being incompatible with the requirements for good growth.

4. Fortnightly spraying of the young fruits in flower for from three to four months with either Bordeaux mixture or lime-sulphur has given very satisfactory results. Bordeaux mixture of the formula 3–4–50 was used during the first month, followed by a more concentrated solution of 4–5–50 for the rest of the period. In the case of lime-sulphur (33° Baumé) the application was at 1 : 80 dilution during the first month and at 1 : 70 afterwards.

5. Under Bukidnon Province conditions two applications with potassium sulphate at the rate of 500 kilos per hectare, the first

during the tenth month and the second during the thirteenth month, have reduced the infection by, approximately, 16 to 17 per cent, aside from the increase obtained in yield of 0.2 kilo per fruit, and the increase in acidity from pH 4 to 3.8.

6. There are indications that the increase in acidity of the cell sap as well as the increase in the firmness of the tissues caused by potash treatment are responsible for the resistance shown against infection.

RECOMMENDATIONS

1. *Spraying.*[3]—Where either or both of the diseases are serious enough to warrant the adoption of control measures, fortnightly spraying of the young fruits in flower for from three to four months with either Bordeaux mixture or lime-sulphur, preferably the former, should be practiced. Bordeaux mixture of the formula 3–4–50 should be used during the first month, followed by a more concentrated solution of 4–5–50 formula for

[3] The spray solutions may be prepared as follows:

Bordeaux mixture (3–4–50).—The solution of this formula may be prepared by dissolving 1.36 kilos (3 pounds) of commercial copper sulphate in 10 liters of water (preferably hot to facilitate solution) in a wooden barrel, to which enough water is added later to make 94.5 liters (25 gallons) of the copper sulphate solution. As much as 1.82 kilos (4 pounds) of high-grade quicklime are slaked in about 10 liters of water, and when cold, it is strained into another wooden barrel and enough water is added to make 94.5 liters (25 gallons) of lime solution. The two dilute solutions are then poured together into a third wooden barrel and the mixture is stirred vigorously.

The preparation of the 4–5–50 formula is exactly the same as the 3–4–50, except that more copper sulphate and stone lime have to be used.

Lime-sulphur.—The standard lime-sulphur (33° Baumé) may be prepared according to the best-known formula, 50–100–50, as follows: To suit the actual needs the amount of the ingredient may be altered proportionally; in this case it was reduced to one-tenth. Some water is placed in an iron cooker set on a fire and 2.27 kilos (5 pounds) of high-grade quicklime are dumped into it to slake. When the slaking is well underway, 4.54 kilos (10 pounds) of sulphur powder are added, followed with some more water to maintain a thin paste. As soon as the slaking is completed, enough water is added to make 18.9 liters. Actually, more water should be added to make up for the loss due to evaporation. The mixture is stirred constantly until it boils and assumes a rich amber color and has a hydrometer reading of 33° Baumé. The solution is drawn off into a settling receptacle and after a day clear liquid is decanted into a barrel for storage. The solution is ready for use at any required dilution.

the rest of the period. If lime-sulphur (33° Baumé) is used instead, the dilution should be 1: 80 during the first month and 1:70 afterwards. In any event, the application should be thorough, completely covering the entire fruit and flowers and the immediately surrounding small leaves with a fine mist of the spray. The solutions, especially Bordeaux mixture, must be fresh and should be applied as soon as prepared. Rightly mixed and freshly prepared, Bordeaux mixture is remarkably adhesive and does not yield easily to the washing action of rains.

2. *Fertilizer application and soil treatment.*—The effect of fertilizer application, most particularly of potassium sulphate, should be thoroughly studied. In Santa Fe, Bukidnon Province, two applications with potassium sulphate at the rate of 500 kilos per hectare in two equal replenishments—once during the tenth month and again during the thirteenth month—have given good results. This should be tried in other districts where similar climatic and soil conditions prevail. Sulphur-powder treatment, or any other soil treatment that would produce fruits of high acidity like those of Hawaii should be tried also.

3. *Breeding and selection.*—Breeding and selection for high acidity in terms of pH value aside from other desirable economic characters should also be pursued. The hybrid obtained in Hawaii by crossing Smooth Cayenne with a Brazilian wild variety, which was reported as possessed of high economic value and high acid content, should be tried in the Philippine Islands.

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ILLUSTRATIONS

PLATE 1

TEXT FIGURES

PLATE 1.

NOTES ON PHILIPPINE MOSQUITOES, II

URANOTAENIA GROUP [1]

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FOUR PLATES AND ONE TEXT FIGURE

Twelve species are discussed in this paper, seven of which are new. Four of the twelve species have previously been reported by various workers, all the others being now for the first time known to occur in the Philippines. So far I have not encountered three of the seven species heretofore credited to the Islands; namely, *Uranotaenia inontata* Dyar and Shannon (1925), *Uranotaenia nivipes* Theobald (1905), and *Uranotaenia pygmaea* Theobald (1901). Undoubtedly there are other species awaiting discovery.

These mosquitoes are the following:

Uranotaenia annandalei Barraud (1926).

Uranotaenia argyrotarsis Leicester (1908).

Reported as *Pseudouranotaenia parangensis* by Ludlow in Theobald, Mon. Cul. 5 (1910).[2]

Uranotaenia atra Theobald (1905).

Reported as *Uranotaenia caeruleocephala* var. *lateralis* by Ludlow (1905); as *atra* by Dyar and Shannon (1925).

[1] This paper was submitted for publication January, 1935. The work was done in the central laboratory of the malaria section, Philippine Health Service, Manila, of which Dr. Antonio Ejercito is chief. I am greatly indebted to Dr. Ejercito for his unbounded moral support and encouragement; to Dr. Paul F. Russell, of the Rockefeller Foundation, for his help, and for allowing me to have all the culicine mosquitoes collected for him; to Director Angel Argüelles, of the Bureau of Science, and Dr. Marcos Tubangui, of the same bureau, for extending to me the free services of the photographic division of the Bureau of Science; to Dr. José Mendiola for inking all the drawings; and to all other personnel of Malaria Investigations and malaria section who have directly or indirectly helped me in this work. I am also very thankful to Mr. Domingo Santiago, of the School of Hygiene and Public Health, University of the Philippines, for allowing me to go over his collection and lending me some specimens for description, and for comparison with my own.

[2] The synonyms given here are in accordance with F. W. Edwards (1932).

Uranotaenia ludlowae Dyar and Shannon (1925).
Uranotaenia testacea Theobald (1905).
Reported as *U. falcipes* by Banks (1906).
Uranotaenia arguellesi sp. nov.
Uranotaenia tubanguii sp. nov.
Uranotaenia lagunensis sp. nov.
Uranotaenia mendiolai sp. nov.
Uranotaenia heiseri sp. nov.
Uranotaenia delae sp. nov.
Uranotaenia reyi sp. nov.

URANOTAENIA ANNANDALEI Barraud.

Uranotaenia annandalei BARRAUD, Ind. Journ. Med. Res. 14 (1926) 343.

Habits.—Larva breeds in forest streams; habits of adults unknown.

Distribution.—Baguio (5,000 feet elevation), Mountain Province (*Baisas*); College of Agriculture, Los Baños, Laguna (*Baisas.*)

Adult (*male and female*).—Head: A border of bluish white scales to eyes, the remainder of head covered with dark brown (dark bluish under certain light) scales, mixed with some upright forked ones on vertex and nape. Tori, clypeus, palpi, and proboscis dark brown. Thorax: Mesonotum dark brown with dark brown scales and dark bristles. A line of bluish white scales from *apn* to pleura, where it joins a bare white patch on mesepimeron. No such scales in front of wing roots but over wing base is a patch of broad grayish brown scales. Some white scales on coxæ. Wings entirely dark-scaled. Abdomen dark above, a little paler beneath. Legs mainly dark, undersides of femora pale.

Male terminalia as illustrated.

Larva.—Head about as long as broad, light brown. Clypeal spines emarginate at tips. *A* finely feathered, slightly flattened, 3-branched [simple in the Indian form according to Barraud (1934) 58 and 76]. *B* and *C* much flattened, dark, spinous laterally, simple; *d* much shorter than *B*, slender, simple; *e* slender, long, simple or forked near base. *Oo* (outer occipital) similar to *e*, 3-branched. Abdomen: *lh* I to III developed, finely feathered. Segment VIII with five to seven comb teeth, which are short, pointed, fringed. Siphon with eight to eleven pecten teeth, which are expanded at tips; tuft finely feathered, 9- to 12-branched, its base situated at about middle of siphon opposite most distal pecten tooth. Anal segment only slightly shorter than siphon, spinous at posterior margin; *isc* and *osc* 2-branched; *lh* short, 2-branched.

URANOTAENIA ARGYROTARSIS Leicester.

Uranotaenia argyrotarsis LEICESTER, Cul. of Malaya (1908) 214. A better description by F. W. Edwards, Bull. Ent. Res. 20 (1929) 312.

Habits.—Larva breeds in forest stream; habits of adults unknown.

Distribution.—Iwahig, Palawan (*Baisas*).

Adult (*male*).—Head: Broad line of bluish white scales to eyes narrowing to a sharp point in front; dark bluish, flat scales cover rest of head, mixed with upright forked ones on vertex and nape. Tori, clypeus, palpi, and proboscis dark brown. Thorax: Pleural line of bluish white scales from *apn* to anterior border of mesepimeron; another line of similar scales from front of wing root to posterior margin of *ppn*. Some white scales on coxæ. Wings mainly dark-scaled; remigium and basal half of stem of vein 5 white-scaled; vein 6 in one specimen has only one dark scale at about middle, two similar scales in the other specimen at about the same situation, the remaining portions bare. Abdomen mainly dark, the pale median apical patches on tergites III and IV ill-marked. Legs mostly dark brown, undersides of femora pale; last three hind tarsal segments and tip of second white. Hind tibia (male) somewhat bent outwardly, and ornamented just before the bend with one straight and two curled bristles. Middle tibia much longer than either fore or hind tibia.

Larva.—Head a little longer than broad, dark brown. Clypeal spines short, stout, pointed. *A* finely feathered, 4- or 5-branched; *B* and *C* much flattened, dark, spinous, simple; *d* slender, 3-branched; *e* long, slender, simple; *oo* similar to *e*, 2-branched. Abdomen: *lh* I and II well developed, finely feathered. Segment VIII: Comb teeth 8 to 10 in number, pointed, fringed. Siphon: Pecten teeth 12 to 14 in number, of the usual type. Tuft finely feathered laterally, 10- or 11-branched, its base situated opposite most distal pecten tooth. Anal segment: *isc* 3-branched; *osc* 2- or 3-branched; *lh* 5-branched.

URANOTAENIA ATRA Theobald.

Uranotaenia atra THEOBALD, Ann. Mus. Nat. Hung. 3 (1905) 114.

Habits.—Larva breeds in forest streams; habits of adults unknown.

Distribution.—Cotabato, Mindanao (*Ludlow*); Iwahig, Palawan (*Baisas*); Calauan, Laguna (*Santiago*); Tungcong Manga, San Jose, Bulacan (*Baisas*).

Adult (*male and female*).—Head: A border of bluish white scales to eyes; rest of head clothed with dark bluish or brownish flat scales, mixed with some upright forked ones on vertex and nape. Tori, clypeus, and palpi brownish; proboscis darker. Thorax: Mesonotum dark brown. Some bluish white scales on *apn*, and a large patch of similar scales on sternopleura; between these may be scattered a few similar scales, but they do not join together to form a continuous line. Some white scales on coxæ. A line of bluish white scales in front of wing root extending to posterior margin of *ppn*. Wings entirely dark-scaled. Abdominal tergites dark with apical white lateral patches; sternites mostly pale. Legs mainly dark-scaled, undersides of femora pale. First fore tarsal segment about two-thirds the length of tibia; of hind leg a little shorter than tibia. Legs of male highly modified. A line of blunt flattened spines at one side of apex of fore tibia is a characteristic not mentioned by other workers. In this respect *U. atra* (male) is similar to female *U. delae* and *U. reyi*, which are described in this paper.

Larva.—(Described from one skin from which a male emerged, kindly lent me by Mr. D. Santiago.) Head: A little longer than broad, brown. Clypeal spines short, stout, pointed. *A* finely feathered, 3-branched; *B* and *C* flattened, spinous at sides, simple; *d* not visible; *e* long, slender, forked apically; *oo* about as long and slender as *e*, 3-branched. Abdominal segment VIII with seven or eight fringed, pointed comb teeth. Siphon with eleven or twelve fringed, apically enlarged pecten teeth. Tuft: Base situated at about middle of siphon opposite the second most distal pecten tooth. Anal segment: *isc* and *osc* 2-branched; *lh* short, 10–branched.

URANOTAENIA LUDLOWAE Dyar and Shannon.

Uranotaenia ludlowae DYAR and SHANNON, Insec. Inscit. Mens. 13 (1925) 68.

Habits.—Larva breeds in large, clear, vegetated pools or marshes; habits of adults unknown.

Distribution.—Parang, Cotabato, Mindanao (*Ludlow*); Simoay, Cotabato, Mindanao (*Baisas*); Calauan, Laguna (*Santiago*).

Adult (*female*).—Head: A broad line of bluish white scales bordering eyes; remaining parts with dark brown scales mixed with some upright forked ones on vertex and nape. Tori and clypeus pale brown; palpi and proboscis much darker. Thorax: Integument of mesonotum brown, scales and bristles darker.

Postnotum dark brown; pleura with some pale patches. A line of bluish white scales in front of wing root extending to posterior margin of *ppn*. Pleural line of similar scales from *apn* broadening on sternopleura where it is formed by five or six rows of scales. These scales are well-spread and hardly overlap one another, whereas in *argyrotarsis* (*parangensis*) there are only three rows of scales, which overlap each other considerably. Wings: In both specimens at hand there are one or two white scales at base of remigium, and the extent of white scaling on vein 6, that is, judging from the description given for *argyrotarsis* (*parangensis*) by Dyar and Shannon (1925), is about as much as in *argyrotarsis*. In one specimen two white scales are mixed with the dark ones on the apical dark half of the stem of vein 5. Vein 6 in one specimen has only a single white scale at about the apex of the basal third, the rest towards the apex dark-scaled, towards the base bare. In the other specimen there is one white scale at about the same situation on vein 6, but basal to it is a single dark scale, the remaining portion basally being bare, and apically dark-scaled. Abdominal tergites dark brown; sternites mainly pale. Legs mostly dark-scaled, undersides of femora pale. Last two hind tarsal segment white, the third pale beneath throughout its entire length, but dark above from base to a short distance before the apex.

Larva.—Head a little longer than broad, brown. Clypeal spines short, stout, pointed. *A* somewhat flattened, spinous, 3-branched; *B* and *C* much more flattened than *A*, dark, spinous laterally, simple; *d* flattened, spinous, simple; *e* long, slender, 2- or 3-branched apically; *oo* finely feathered, 5- or 6-branched. Antenna as illustrated. Abdomen: *lh* I and II developed. Segment VIII with eight or nine comb teeth, which are pointed, fringed. Siphon with eleven or twelve pecten teeth of the usual type. Tuft scantily feathered, 11 to 16-branched, its base opposite the second most distal pecten tooth. Anal segment: *osc* missing; *isc* 4- or 5-branched; *lh* 9- to 14-branched.

URANOTAENIA TESTACEA Theobald.

> *Uranotaenia testacea* THEOBALD, Ann. Mus. Nat. Hung. 3 (1905) 113.

Habits.—Larva breeds in forest stream; habits of adults unknown.

Distribution.—Rizal waterworks, Camp 320, Manila (*Banks*); Tungcong Manga, San Jose, Bulacan (*Baisas*).

Adult (*male and female*).—Head: Extensive bluish white scales to eye margins, broadening at sides; remaining areas clothed with dark flat scales, mixed with some upright forked ones on vertex and nape. Thorax: Pleural line of bluish white scales covers *apn* and extends to anterior margin of mesepimeron. No line of such scales in front of wing roots. Wings entirely dark-scaled. Abdomen dark above, much paler beneath. Legs mostly dark brown, undersides of femora pale. Unlike the Indian form, the local species has the whole of the last three hind tarsal segments and apex of the second completely white.

URANOTAENIA ARGUELLESI sp. nov.

Type.—Male (lot R40–xx) and female (lot R40–yy).

Cotypes.—Two males and 2 females. Types and cotypes in the collection of the Bureau of Health, Manila.

Type locality.—Calauan, Laguna, Luzon.

Collector.—F. E. Baisas.

Date of collection.—February 25, 1930.

Habits.—Larva breeds in impounded, clear, vegetated water; habits of adults unknown.

Distribution.—Known only from the type locality.

Adult (*male and female*).—Head: A well-defined line of bluish white scales to eye margins, forming a sharp point in front; remaining portions of head covered with dark, flat scales, mixed with some upright, forked scales on vertex and nape. Tori and clypeus brown; proboscis slightly shorter than front femur, dark brown. Thorax: Integument of mesonotum dark brown, scales dark brown, bristles darker. A line of bluish white scales in front of wing root to posterior margin of *ppn*. A similar line runs across pleura, including *apn*, to anterior margin of mesepimeron. Postnotum and pleura dark brown. Wings mostly dark-scaled; extreme base of costa white in some individuals; remigium, basal half of stem of vein 5, and basal third to half of vein 6 white-scaled. *Af* not much smaller than *pf*. Abdominal tergites I to III completely white dorsally, IV white apically, V with complete apical band. VI and VII entirely dark. Sternites mostly pale. Legs mainly dark-scaled, undersides of femora pale.

Male terminalia as figured.

Larva.—Head a little longer than broad, very dark. Clypeal spines short, stout, pointed. *A* slightly flattened, finely feathered, 4- or 5-branched; *B* and *C* flattened, dark spinous laterally, simple; *d* slender, 2-branched; *e* slender, long, forked

apically or about middle; *oo* about as long and slender as *e*, 3-branched. Abdomen: Segment VIII with eight or nine comb teeth, which are pointed, fringed. Siphon with about twelve pecten teeth, which are much enlarged apically, fringed. Tuft finely feathered, 12-branched, its base opposite most distal pecten tooth. Anal segment: *isc* 3-branched; *osc* 2-branched; *lh* 5- or 6-branched.

This species is named for Dr. Angel S. Argüelles, director of the Bureau of Science.

URANOTAENIA TUBANGUII sp. nov.

Type.—Male [lot R110 (a)-1], and female [lot R110 (a)-2].

Cotypes.—Six males and 4 females. Types and cotypes in the collection of the Bureau of Health, Manila.

Type locality.—Kolambugan, Lanao, Mindanao.

Collector.—F. E. Baisas.

Date of collection.—July 30, 1934.

Habits.—Larva breeds in large numbers in tree holes; many adults near the point of breeding, apparently not human biters.

Distribution.—Known also from the mountains of Calauan, Laguna (*Santiago*).

Adult (male and female).—Head with a patch of dull bluish white scales on lateral sides to eye margins, continued to front by a narrow line of dull pale brown scales; remaining parts clothed with dark brown (dark bluish under certain light) scales, mixed with upright, forked, dark scales (whose apices are much more expanded than in other species) on vertex and nape to near eye margins. Tori, clypeus, and palpi dark brown. Proboscis about five-eighths the length of front femur, dark brown. Thorax: Mesonotum dark brown, scales paler, bristles rather few, dark. In front of wing roots along margin of mesonotum to front is a line of pale scales visible as a broad pale line under a certain angle. It is not, however, like the usual bluish white scales found in other species, although a few scales immediately near the wing roots are broader. Postnotum paler than integument of mesonotum. Pleura including *apn* devoid of scales. The upper portion of pleura from a line following lower margin of mesepimeron distinctly dark brown; the lower part including coxæ and trochanters paler. Indefinite black areas scattered on upper portion of pleura. Wings entirely dark-scaled. *Af* distinctly smaller than *pf*. Legs dark brown, undersides of femora pale; no peculiar modifications. Abdominal tergites entirely dark; sternites scarcely less so.

Larva.—Head about as long as broad, light brown. Clypeal spines directed upwards, less stout, and shorter than in other species. *A* long, slender, simple; *B* and *C* longer than *A*, slender, simple; *d* small, 4- or 5-branched; *e* long, slender, 2- or 3-branched apically; *oo* very small, 5- to 7-branched. Thorax much broader and thicker than in other species. One of the anterior, submedian, thoracic hairs unusually long, extending beyond the rim of head by about half its length. Abdomen: *lh* I and II finely feathered, developed, simple. Segment VIII with eight to ten pointed, fringed comb teeth. Siphon much longer than in other species (index 5). Sixteen or seventeen pecten teeth, short, fringed, expanded apically. Tuft 2- to 4-branched, its base situated about midway between most distal pecten tooth and apex of siphon. Anal segment of the usual type; *isc* and *osc* each simple; *lh* short, simple.

Larva is easily determined macroscopically by the presence of a large white patch on thorax.

This species is named for Dr. Marcos A. Tubangui, of the Bureau of Science.

URANOTAENIA LAGUNENSIS sp. nov.

Type.—Male (lot F149) and female (lot F149–5) with larval skin.

Isotypes.—Eight males and 7 females. Types and isotypes in the collection of the Bureau of Health, Manila.

Type locality.—College of Agriculture, Los Baños, Laguna.

Collector.—F. E. Baisas.

Dates of collection.—March 17, 1930, and November 4, 1934.

Habits.—Larva breeds in rock holes in forest creek; habits of adults unknown.

Distribution.—Found also in Limay, Bataan (*United States Army Medical Department Research Board*); and Iwahig, Palawan (*Baisas*).

Adult (*male and female*).—Head covered with brown scales, those along the eyes paler, but not forming a distinct white line. Dark, upright, forked scales having tips about as expanded as those of *tubanguii* scattered on vertex and nape to near eye margins. Clypeus and palpi dark brown. Tori lighter in color. Proboscis about four-fifths the length of front femur, dark brown. Thorax: Integument of mesonotum as well as postnotum and pleura brown; mesonotal scales brown, bristles numerous, dark. No line of bluish white scales in front of wing roots or on pleura. Dark brown flat scales cover *apn;*

a large patch of similar scales on sternopleura; similar scales scattered elsewhere on pleura and coxæ. Wings entirely dark-scaled. *Af* much smaller than *pf*. Abdominal tergites dark with distinct pale basal bands on II to VII; sternites pale. Legs mostly dark-scaled, undersides of femora pale. First hind tarsal segment in both sexes longer than tibia.

Male terminalia as illustrated.

Larva.—Head about as long as broad, brown. Clypeal spines stout, short, pointed, brown. *A* finely feathered, 4- to 6-branched; *B* and *C* long, narrow, only slightly flattened, finely spinous laterally, simple; *d* posterior but internal to *C*, and anterior to *B*, small, 3-branched; *e* slender, simple, or forked at about middle; *oo* finely feathered, 2-branched. Antenna as figured. Abdomen: *lh* I and II developed, finely feathered. Segment VIII with ten or eleven pointed, fringed comb teeth. Siphon with about twenty-four to twenty-eight pecten teeth of the usual type. Tuft finely feathered, 6- to 8-branched, its base variably situated opposite either one of the three most distal pecten teeth. Anal segment of the usual type; *isc* and *osc* 2-branched; *lh* finely feathered, 2-branched.

URANOTAENIA MENDIOLAI sp. nov.

Type.—Male (lot F153–7) and female (lot F153–5) with their larval skins.

Cotypes.—Eight males and 3 females.

Isotypes.—One male and 2 females. Types, cotypes, and isotypes in the collection of the Bureau of Health, Manila.

Type locality.—College of Agriculture, Los Baños, Laguna.

Collector.—F. E. Baisas.

Dates of collection.—March, 1930; November, 1934; and January, 1935.

Habits.—Larva breeds in rock holes in forest creek, also along stagnated clear edges of creek; habits of adults unknown.

Distribution.—Known also from Limay, Bataan (*United States Army Medical Department Research Board*).

Adult (male and female).—Head mainly clothed with dark, broad, flat scales; a border of bluish white scales to eyes continued to front; a few dark, upright, forked scales on nape. Tori, clypeus, and palpi dark brown. Proboscis about three-fourths the length of front femur, dark above, somewhat paler beneath. Thorax: Mesonotal scales and integument dark brown; bristles darker. A line of bluish white scales in front of wing root, extending along border to front of mesonotum. A similar

line on pleura from *apn* to anterior border of mesepimeron where it joins a pale bare patch. Similar scales scattered elsewhere on pleura and coxæ. Postnotum dark brown. Wings mostly dark-scaled; remigium and a varying portion of base of vein 1 white-scaled; in some individuals there are a few dark scales on anterior apical border of remigium. *Af* smaller than *pf*. Abdominal tergites I and II completely white dorsally; III and IV with median apical white patches; V and VI with complete apical white bands; VII entirely dark. Sternites dark brown. Legs mostly dark brown, undersides of femora pale. A line of white scales in front of midfemur, extending from base to about two-thirds or more the length of the segment. Femora and tibia with pale apices; fore and midtarsi except the last pale at the joints; hind tarsal segments 1 to 3 with pale apical and basal rings; last two segments completely white in most individuals, imperfectly so in some.

Male terminalia as illustrated.

Larva.—Head a little longer than broad, very dark. Clypeal spines of the usual type. *A* finely feathered, slightly flattened, 3- to 5-branched; *B* and *C* much flattened, spinous laterally, dark; *d* very slender, 2- or 3-branched; *e* slender, forked at a little beyond the middle towards the apex; *oo* 3-branched. Abdomen: *lh* I and II finely feathered, developed. Segment VIII with eight to ten comb teeth, which are pointed, fringed. Siphon with about fourteen pecten teeth, of the usual type. Tuft: Base situated at about middle of siphon opposite the most distal pecten tooth, finely feathered, about 12-branched. Anal segment: *isc* 3-branched; *osc* 2-branched; *lh* 4- or 5-branched.

This species is named for Dr. J. Mendiola, of the Bureau of Health.

URANOTAENIA HEISERI sp. nov.

Type.—Female (lot R85–1) with its larval skin, in the collection of the Bureau of Health, Manila.

Type locality.—Parang, Cotabato, Mindanao.

Collector.—F. E. Baisas.

Date of collection.—July 5, 1934.

Habits.—Larva breeds in fresh-water swamps; habits of adults unknown.

Distribution.—Known only from the type locality.

Adult (female; male unknown).—Head mainly covered with broad, flat, dark scales, mixed with a few upright forked scales on vertex and nape. A border of a well-defined line of bluish

white scales to eyes, meeting in a sharp point in front. Tori, clypeus, and palpi dark. Proboscis about three-fourths the length of front femur, dark brown. Thorax: Integument and scales of mesonotum dark brown; bristles darker. A line of bluish white scales from front of wing root to posterior margin of *ppn*. Postnotum brown; pleura darker. Another line of bluish white scales from *apn* to pleura terminating at the anterior border of mesepimeron where it meets a pale bare patch. Some white scales on coxæ. Wings mostly dark-scaled. Remigium and a short portion of base of vein 1 white-scaled. Abdomen entirely dark dorsally; a white, apical, lateral patch on V. Venter of abdomen paler. Legs dark brown, undersides of femora pale. No peculiar modifications.

Larva.—Head longer than broad, very dark. Clypeal spines of the usual type. *A* finely feathered, slightly flattened, 3-branched. *B* and *C* much flattened, spinous laterally, dark, simple. *d* not visible; *e* and *oo* missing. Antenna as figured. Abdomen: *lh* I and II finely feathered, developed. Segment VIII with six or seven pointed, fringed comb teeth. Siphon with eleven pecten teeth, which are shorter and much more expanded at apices than in other species; tuft unfeathered, 12-branched, its base situated opposite the most distal pecten tooth. Anal segment: *isc* 3-branched; *osc* missing; *lh* 5- to 7-branched.

This species is named for Dr. Victor G. Heiser, of the Rockefeller Foundation.

URANOTAENIA DELAE sp. nov.

Type.—Female (lot R83-30) with its larval skin, in the collection of the Bureau of Health, Manila.

Type locality.—Salimbao, Cotabato, Mindanao.

Collector.—F. E. Baisas.

Date of collection.—July 4, 1934.

Habits.—Larva breeds in fresh-water marsh; habits of adults unknown.

Distribution.—Known only from the type locality.

Adult (female; male unknown).—Head mainly covered with dark, broad, flat scales dorsally, mixed with a few upright, forked scales on vertex and nape. A broad line of bluish white scales to border of eyes meeting in a point at front. Antennæ, clypeus, and palpi dark brown. Proboscis about as long as front femur, dark brown above, paler beneath at middle. Thorax: Integument, and scales of mesonotum dark brown. Postnotum dark brown. A line of bluish white scales in front

of wing root extending to posterior margin of *ppn*. Another line of similar scales from *apn* to anterior margin of mesepimeron. Wings mainly dark-scaled; posterior margin of remigium and basal fourth of stem of vein 5 white-scaled. *Af* much smaller than *pf*. Abdomen dark brown dorsally, a little paler beneath. Legs mostly dark-scaled, undersides of femora pale; last three hind tarsal segments and apex of second white. Fore tibia with peculiar ornamentation (as illustrated) at apex; second tarsal segment distinctly shorter than either the first or the third, thickened with numerous long hairs on one side and a line of well-separated long hairs on the side opposite. Midtibia very much longer than femur or first tarsal segment; last three tarsal segments very short and somewhat thickened, all the three together only about one-half as long as the second. First hind tarsal segment about as long as tibia.

Larva.—Head about as long as broad, fairly dark. Clypeal spines short, stout, dark. *A* long, somewhat flattened, finely feathered, 2-branched; *B* and *C* much flattened, dark, simple, spinous laterally; *d* about as broad as, but longer than, *A*, simple; *e* small, simple; *oo* 5-branched. Antenna as illustrated. Abdomen: *lh* I and II finely feathered, developed. Segment VIII with eight or nine comb teeth, which are pointed, fringed. Siphon with ten or eleven pecten teeth, which are expanded at tips, fringed. Tuft 8-branched, its base situated opposite the second or the third most distal pecten tooth. Anal segment of the usual type; *isc* 3-branched; *osc* 2-branched; *lh* 4-branched.

URANOTAENIA REYI sp. nov.

Type.—Female (lot R94–22) with its larval skin.

Cotypes.—Two females, one of which has its larval skin. Another female with its larval skin collected from a nearby locality. All these are in the collection of the Philippine Health Service, Manila.

Type locality.—Simoay, Cotabato, Mindanao.

Collector.—F. E. Baisas.

Date of collection.—July 9, 1934.

Habits.—Larva breeds in wide, vegetated, clear pool or marsh; habits of adults unknown.

Distribution.—Known also from Parang, Cotabato, Mindanao.

Adult (*female; male unknown*).—Head with a wide border of bluish white scales to eyes; dark, broad, flat, and upright, forked scales on vertex and nape. Tori and clypeus brown; palpi darker. Proboscis slightly shorter than front femur, dark

brown above, paler beneath. Thorax: Mesonotum dark brown. A line of bluish white scales in front of wing root, extending to posterior margin of *ppn*. A broader line of similar scales from *apn* to pleura where it expands considerably as it reaches

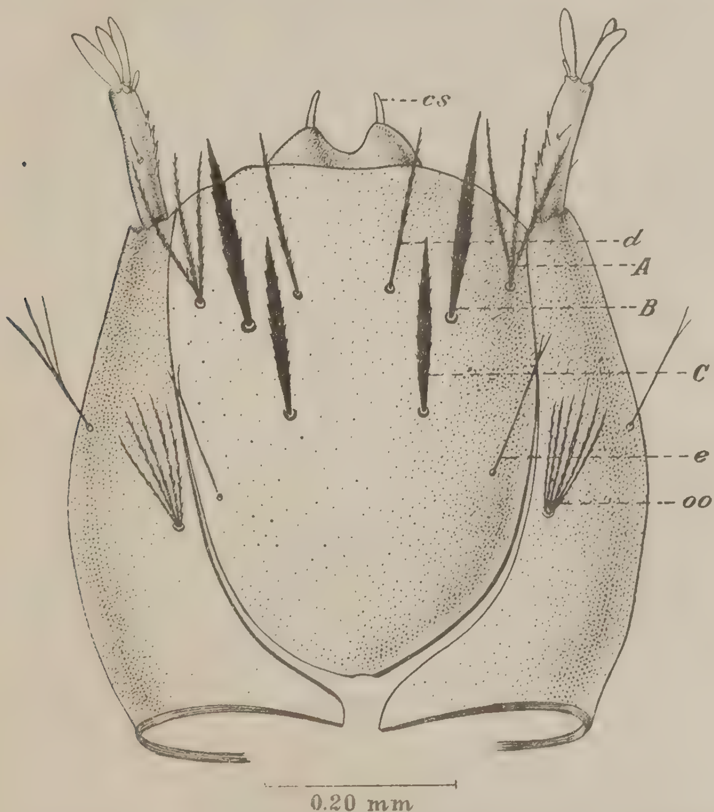

FIG. 1. *Uranotaenia reyi* sp. nov.; head, showing hairs of diagnostic value, in accordance with Edwards (1928) 338. (From a camera-lucida drawing.)
A, Outer postantennal hair of Lang.
B, Mid postantennal hair of Lang.
C, Inner postantennal hair of Lang.
d, Preantennal hair of Lang.
e, Vertical hair of Lang.
oo, Outer occipital hair.
cs, Clypeal spine.

the sternopleura, and joins a white bare patch on mesepimeron. Postnotum dark brown; pleura a little less so. Wings mainly dark-scaled; lower border of remigium and a little less than basal third of stem of vein 5 white-scaled. In one individual

only about basal one-fourth of stem of vein 5 is white and among these white scales is mixed a black one. Vein 6 in all specimens scaleless or with only one or two dark scales at about the middle. *Af* much smaller than *pf*. Abdominal tergites dark brown with pale lateral patches more conspicuous in some individuals or in some segments than in others. Legs mostly clad with dark scales, undersides of femora pale; last three hind tarsal segments and a varying portion of the apex of second white. Fore tibia with a bunch of long bristles apically on one side and a row of blunt-ended, flattened spines similar to those of *delae* or *atra* (as illustrated). First fore tarsal segment, with numerous long hairs basally, distinctly shorter than tibia; second segment still shorter, but not ornamented as that of *delae;* third longer than first, and fourth about three times as long as fifth. Midtibia very much longer than femora, twice as long as first tarsal segment; second, half as long as first; third, over half as long as second; fourth, very short and stout, shorter than fifth, the last three segments together a little longer than second. First hind tarsal segment shorter than tibia.

Larva.—Head a little longer than broad, dark brown; clypeal spines of usual type. *A* somewhat flattened, finely feathered, 3-branched; *B* and *C* flattened, spinous laterally, simple; *d* fairly stout, spinous laterally, simple; *e* long, slender, forked at extreme apex; *oo* finely feathered, 5- to 8-branched. Antenna as figured. Abdomen: *lh* I and II finely feathered, developed. Segment VIII with eight to ten pointed, fringed comb teeth. Siphon with eleven or twelve pecten teeth, of the usual type. Tuft finely feathered, 13- to 15-branched, its base situated opposite the second most distal pecten tooth. Anal segment of the usual type; *isc* 5-branched; *osc* 2-branched; *lh* finely feathered, 9 to 12-branched.

Key to the adults of Philippine species of Uranotaenia.

1. Wings entirely dark-scaled .... 2.
   Wings with some white scales .... 3.
2. Pleura with conspicuous lines or patches of bluish white scales .... 4.
   Pleura bare or with patches of brownish scales .... 5.
3. Hind tarsi with white markings .... 6.
   Hind tarsi entirely dark .... 7.
4. Hind tarsi with white markings .... *testacea.*
   Hind tarsi entirely dark .... 8.
5. Abdominal tergites with white basal bands .... *lagunensis.*
   Abdominal tergites entirely dark .... *tubanguii.*
6. Female foreleg markedly modified; male unknown .... 9.
   Female foreleg not modified .... 10.

7. Abdominal tergites I to IV with white median patches; V with complete apical band .... *arguellesi.*
   Abdominal tergites I to V without white median patches, but terminal ones with pale lateral patches........................ *heiseri.*
8. A line of bluish white scales from wing root to posterior margin of *ppn;* male legs highly modified........................ *atra.*
   No such line of bluish white scales, but some grayish brown scales over wing root .... *annandalei.*
9. First fore tarsal segment with outstanding hairs towards the base; second without such hairs .... *reyi.*
   First fore tarsal segment with no outstanding hairs, but second with numerous outstanding hairs .... *delae.*
10. Abdominal tergites entirely dark-scaled; hind tibia of male without curled bristles .... *ludlowae.*
   Abdominal tergites I to V with median apical white patches; VI and VII completely banded apically; hind tibia of male without curled bristles .... *mendiolai.*
   Abdominal tergites III and IV only with pale median patches; hind tibia of male with curled bristles .... *argyrotarsis.*

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ILLUSTRATIONS

Plate 1. Modification of Legs

Fig. 1. *Uranotaenia atra* Theobald; tip of fore tibia, first fore tarsal segment, and base of second tarsus.

2. *Uranotaenia reyi* sp. nov., tip of fore tibia and base of first fore tarsal segment.
3. *Uranotaenia delae* sp. nov., tip of fore tibia and base of first fore tarsal segment.

Plate 2. Coxite and Style of Male Terminalia and Legs

Fig. 1. *Uranotaenia testacea* Theobald.

2. *Uranotaenia arguellesi* sp. nov.
3. *Uranotaenia tubanguii* sp. nov.
4. *Uranotaenia annandalei* Barraud.
5. *Uranotaenia atra* Theobald.
6. *Uranotaenia argyrotarsis* Leicester.
7. *Uranotaenia mendiolai* sp. nov.
8. *Uranotaenia lagunensis* sp. nov.
9. *Uranotaenia delae* sp. nov., second fore tarsal segment.
10. *Uranotaenia argyrotarsis* Leicester, hind tibia.

Plate 3. Antennæ of Larvæ

Fig. 1. *Uranotaenia arguellesi* sp. nov.

2. *Uranotaenia annandalei* Barraud.
3. *Uranotaenia mendiolai* sp. nov.
4. *Uranotaenia heiseri* sp. nov.
5. *Uranotaenia tubanguii* sp. nov.
6. *Uranotaenia atra* Theobald.
7. *Uranotaenia argyrotarsis* Leicester.
8. *Uranotaenia delae* sp. nov.
9. *Uranotaenia lagunensis* sp. nov.
10. *Uranotaenia ludlowae* Dyar and Shannon.
11. *Uranotaenia reyi* sp. nov.

Plate 4. Portions of Heads of Larvæ Showing Diagnostic Hairs

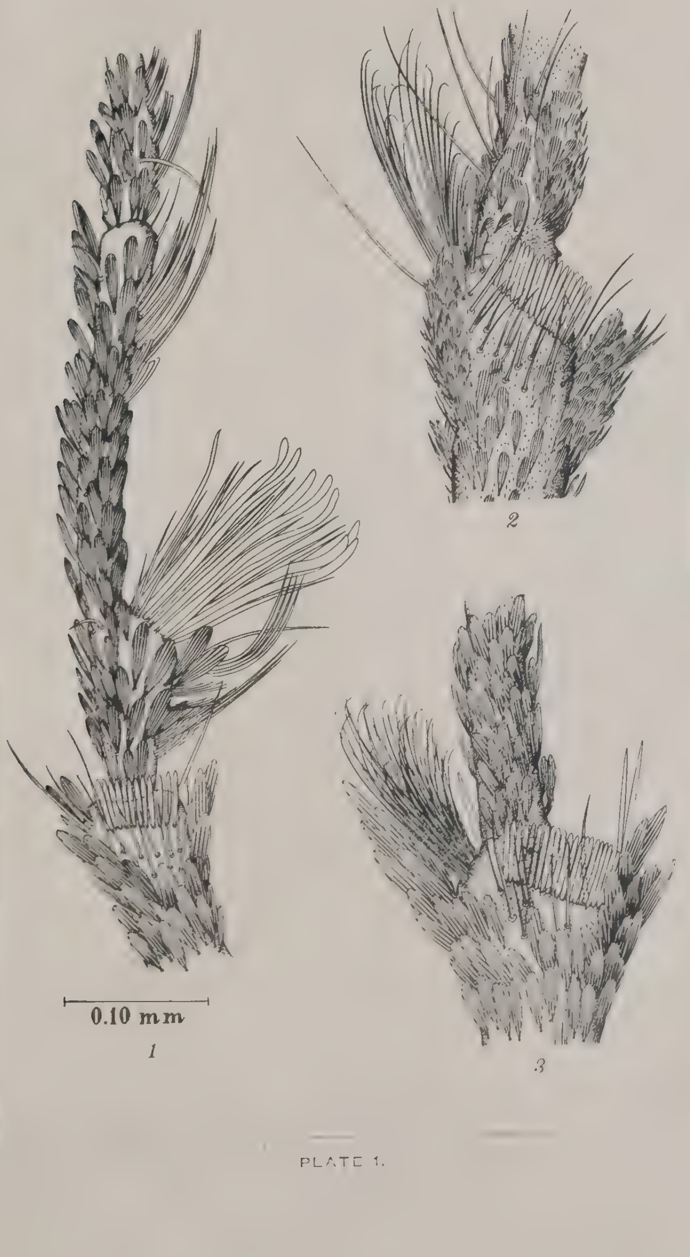
Fig. 1. *Uranotaenia delae* sp. nov.

2. *Uranotaenia heiseri* sp. nov.
3. *Uranotaenia reyi* sp. nov.
4. *Uranotaenia ludlowae* Dyar and Shannon.
5. *Uranotaenia tubanguii* sp. nov.
6. *Uranotaenia argyrotarsis* Leicester.
7. *Uranotaenia arguellesi* sp. nov.
8. *Uranotaenia mendiolai* sp. nov.
9. *Uranotaenia annandalei* Barraud.
10. *Uranotaenia lagunensis* sp. nov.
11. *Uranotaenia atra* Theobald.

TEXT FIGURE

FIG. 1. *Uranotaenia reyi* sp. nov.; head, showing hairs of diagnostic value, in accordance with Edwards (1928) 338. (From a camera-lucida drawing.)

A, Outer postantennal hair of Lang.
B, Mid postantennal hair of Lang.
C, Inner postantennal hair of Lang.
d, Preantennal hair of Lang.
e, Vertical hair of Lang.
oo, Outer occipital hair.
cs, Clypeal spine.



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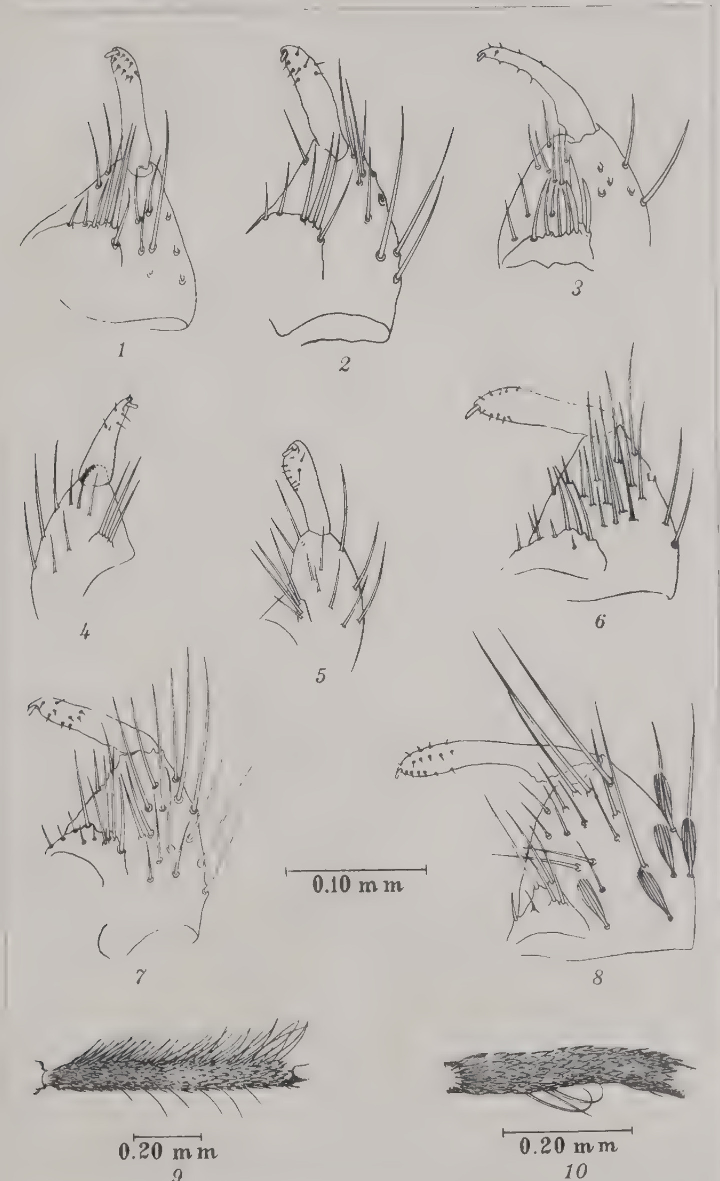

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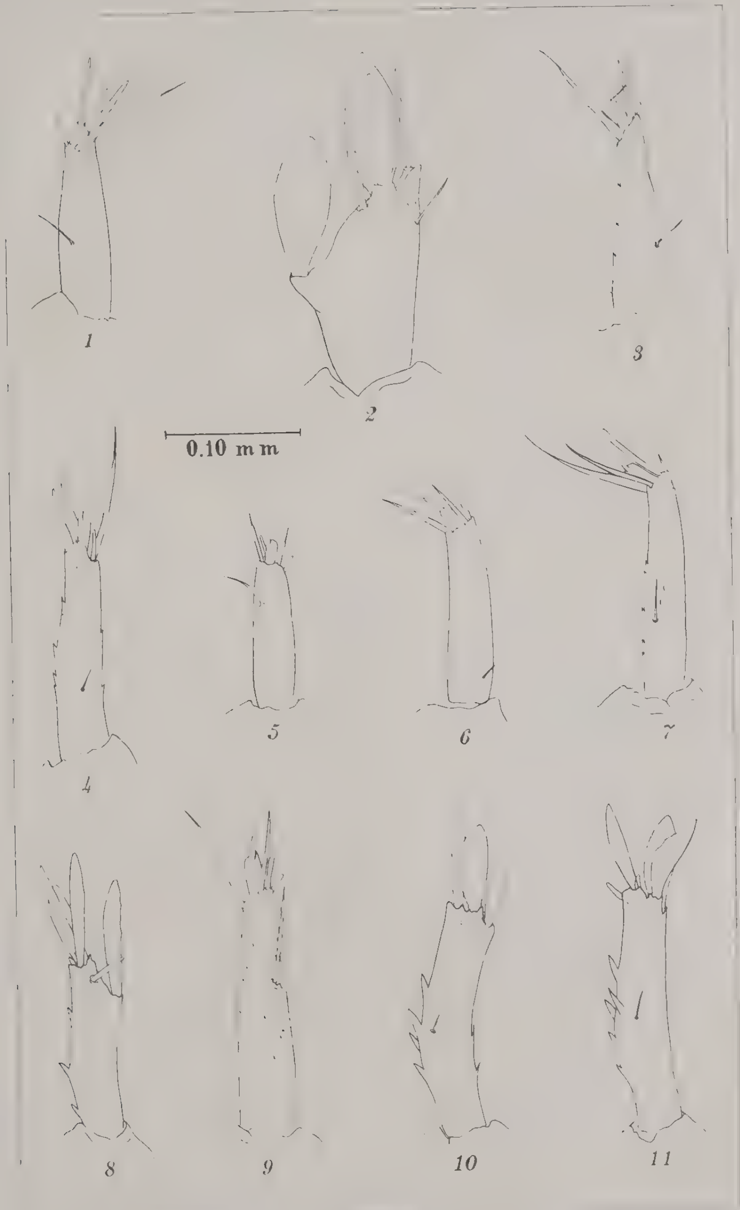
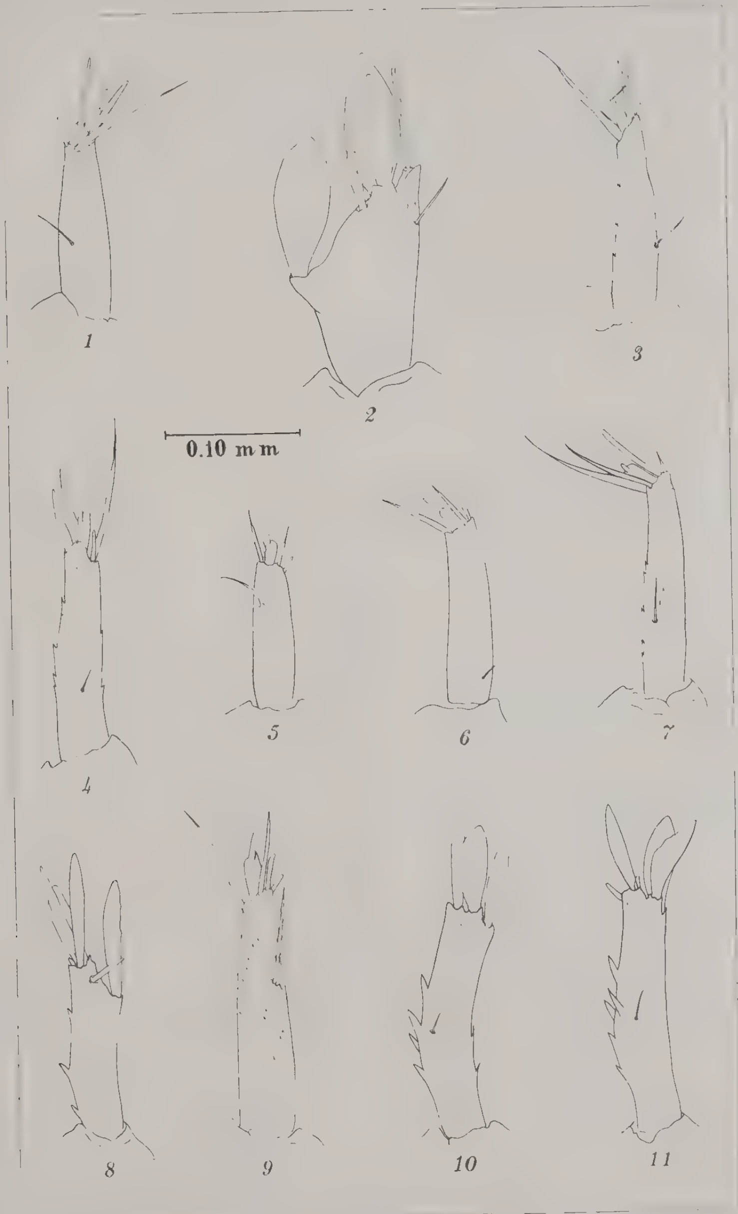


PLATE 3.



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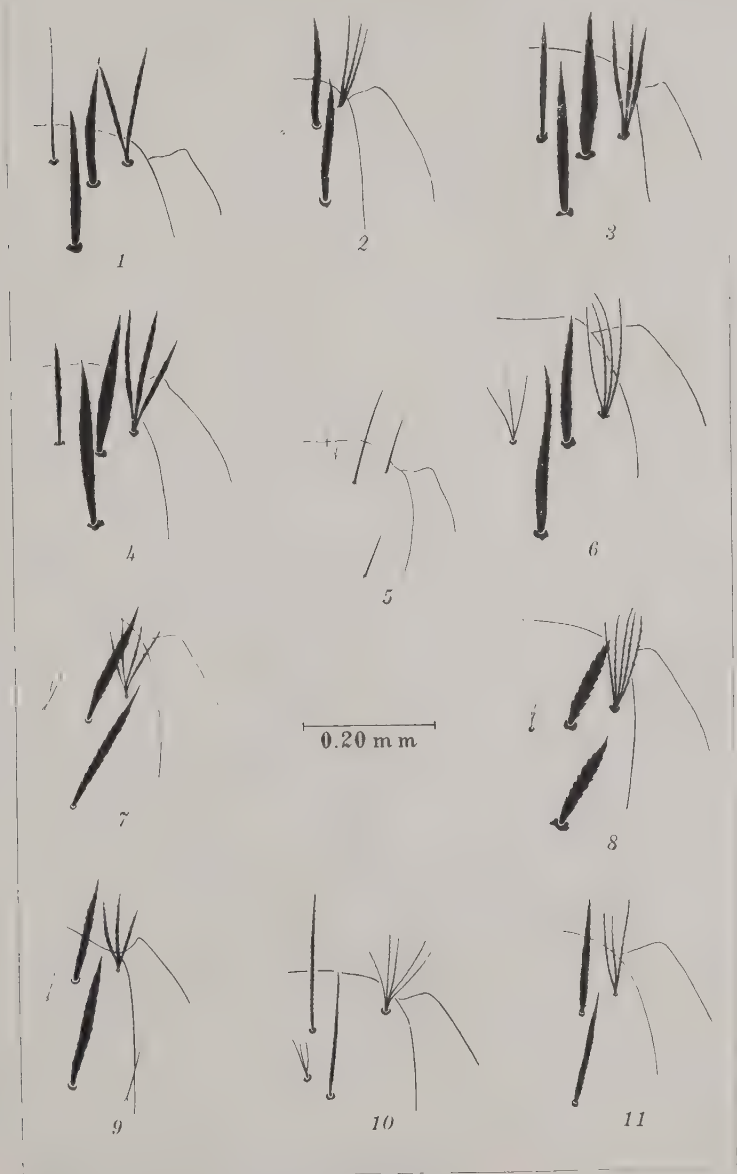

PLATE 4.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XXV [1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

FOUR PLATES

In the present report I have considered a series of tipuline crane flies, all from Szechwan, western China, with the exception of two species, of which specimens were sent to me some years ago from Chekiang, by Mr. E. Suenson. The rich material discussed herewith is, in large part, collections made by the Rev. Mr. David C. Graham, and the resulting types are preserved in the United States National Museum. Still other species were taken on Mount Omei by the Rev. Mr. George M. Franck, and this material is preserved in my own collection. A few additional species were secured by Herr Friedrich, the types of which are preserved in the Deutsches Entomologisches Museum, Berlin-Dahlem, from whence they were loaned to me for study through the kind interest of Dr. Walther Horn. I record here my deepest thanks to each of the above-mentioned entomologists for this continued kindly coöperation.

At the same time I have discussed in some detail the species of *Tipula* in eastern Asia and have attempted to assign each of the numerous described forms to its proper subgenus.

TIPULINÆ

Genus TIPULA Linnæus

Tipula LINNÆUS, Systema Naturæ ed. 10 (1758) 585.

Nearly one-half of all the species of *Tipula* that have been described to date occur within the faunal limits considered in the present report. This vast series of more than 400 species has become increasingly difficult to handle, following the accession in recent years of numerous additions to an already cumbersome list. It, therefore, seems appropriate at this time to record the species known from this area and to make an attempt

[1] Contribution from the entomological laboratory, Massachusetts State College.

to place them in subgeneric groups, a first noteworthy effort toward which was made by Edwards in 1931.[2]

The key that is provided is tentative only and of necessity has been based in part on male and female sexual characters. In defining the subgeneric groups and recording the range of characters in each, particular stress has been devoted to the subgenotype of the various groups, virtually all of which have been available for study. The species have been distributed into what seem to be their proper subgenera, but authentic specimens of a considerable number of species have not been available to me and the assignment of such forms is entirely provisional. There remain further various species that are so aberrant in their characters that it seems inadvisable at this time to attempt to place them definitely in subgeneric groups, and these forms are recorded in a separate list.

A vast amount of work remains to be done upon this genus in eastern Asia, and the present attempt must be held as being merely preliminary. Despite the high percentage of species in this faunal area as compared with the remainder of the World, it seems probable that this will not be materially lowered following the continued discovery of new forms. The Himalayan region, Tibet and western China, together with the mountains of Indo-China and the Malayan islands, all appear to support a rich fauna in this group, only poorly known at the present time. It seems improbable to me that the discovery of novelties in this genus in Europe, Africa, North America, and South America will much more than keep pace with their continued development in eastern Asia. It should be further emphasized that New Zealand and the Polynesian islands have no species of *Tipula* and that to this date only two species (*Indotipula*) have been taken in Australia, which are included in this report in order to complete the data.

The species are recorded in this paper under three geographic units, defined as follows:

1. *Palæarctic Eastern Asia.*—Eastern Siberia; Manchukuo; Korea; Japan; Formosa; eastern China, south to 30° north latitude.

2. *Palæarctic Central Asia.*—Central and Arctic Siberia; Mongolia; Sinkiang; western China, including Kansu, Szechwan,

[2] Ann. & Mag. Nat. Hist. X 8 (1931) 73–82.

Kweichow, and Yunnan; Tibet; the Himalayan region, including Kashmir, eastern Punjab, Garhwal, Nepal, Sikkim, and Bhutan, as well as the Himalayan northern sections of Assam and Burma.

3. *Oriental Eastern Asia.*—Eastern China, south of 30° north latitude; India, Assam, and Burma, south of the Himalayas; Siam; French Indo-China; Malay Peninsula; East Indian Archipelago, including New Guinea and satellite islands; northern Australia.

I include Formosa in the Palæarctic Region despite it geographic position south of 30° north latitude. Most of the crane flies so far taken on the island, including all species of *Tipula*, are from high altitudes where conditions are definitely Palæarctic.

The subgenera of Tipula in central and eastern Asia.

1. *Brithura* Edwards.
2. *Nippotipula* Matsumura.
3. *Sinotipula* subg. nov.
4. *Trichotipula* Alexander.
5. *Schummelia* Edwards.
6. *Formotipula* Matsumura.
7. *Tipula* Linnæus.
8. *Yamatotipula* Matsumura.
9. *Acutipula* Alexander.
10. *Indotipula* Edwards.
11. *Papuatipula* Alexander.
12. *Tipulodina* Enderlein.
13. *Arctotipula* Alexander.
14. *Vestiplex* Bezzi.
15. *Oreomyza* Pokorny.
16. *Lunatipula* Edwards.

A key to the subgenera of the genus Tipula in central and eastern Asia, based in part on sexual characters.

1. Outer cells of wing with macrotrichia .... 2.
   Cells of wing without macrotrichia .... 4.
2. Squama with setæ .... 5. *Schummelia.*
   Squama naked .... 3.
3. Rs elongate, exceeding twice the length of m-cu, the latter at near midlength of cell 1st M_2 .... 15. *Oreomyza.*
   Rs short, subequal to m-cu, the latter just beyond the fork of M, close to the base of cell 1st M_2 .... 4. *Trichotipula.*
4. Vein Sc_1 present .... 1. *Brithura.*
   Vein Sc_1 lacking .... 5.
5. Rs in alignment with R_{4+5}, the basal deflection of the latter lacking; m-cu uniting with M_{3+4} some distance before fork of latter, very rarely (*phædina*) at fork; Rs unusually long, fully twice m-cu; anepisternum with setæ .... 2. *Nippotipula.*
   Basal section of R_{4+5} present; m-cu at fork of M_{3+4} or beyond on base of M_4; Rs of moderate length, ranging to one-half longer than m-cu, in some cases (as *Yamatotipula*, *Sinotipula*, *Vestiplex*, and *Oreomyza*) attaining to fully twice this length, but, if so, with the basal section of R_{4+5} preserved; anepisternum glabrous .... 6.

6. Anterior vertex produced, a slender simple lobe; pleurotergal tubercle large, with velvetlike pubescence on dorsal face; body very stout; often with setæ on dorsal sternopleurite........ 1. *Brithura.*
   Anterior vertex without such a lobe, at most merely protuberant; pleurotergite not elevated into a tubercle; body relatively slender; sternopleurite glabrous (except in some species of *Arctotipula, Vestiplex,* and *Lunatipula*) .... 7.
7. Body coloration contrasted black and orange, the thorax either chiefly velvety black or else a shade of orange or reddish; ovipositor with short fleshy valves; male hypopygium with a single complex dististyle. 6. *Formotipula.*
   Body coloration not contrasted black and orange as above; ovipositor with elongate sclerotized cerci (except in *Arctotipula* and some *Lunatipula* species); male hypopygium with two dististyles........ 8.
8. Legs very elongate, with snowy-white rings on femora, tibiæ, or tarsi. 12. *Tipulodina.*
   Legs of moderate length, without white rings........ 9.
9. Fore tibiæ without spurs........ 10. *Indotipula.*
   Fore tibiæ with a single spur........ 10.
10. Wings with m-cu unusually long, so cell M_4 is very deep and much wider at base than at margin; vein Cu_1 not conspicuously constricted at point of insertion of m-cu; male hypopygium with a compressed median blade on tergite or else with caudal margin notched. 5. *Schummelia.*
    Wings with m-cu of moderate length, so cell M_4 is short and but little wider at base than at margin; Cu_1 more constricted or shirred at point of insertion of m-cu; male hypopygium with tergite not extended into a median compressed blade (where with a median lobe, as *Tipula, Yamatotipula, Acutipula,* and *Indotipula*, this depressed and set with microscopic spicules at and near apex)........ 11.
11. Ovipositor with hypovalvæ greatly reduced, the cerci correspondingly large, heavily sclerotized, placed horizontally and with the outer margins serrate; male hypopygium with the caudal portion of tergite often with a shallow, blackened, saucerlike portion, or else completely divided on midline by pale membrane; many species with an acute spine at caudal portion of basistyle; claws (male) simple. 14. *Vestiplex.*
    Ovipositor with well-developed hypovalvæ; cerci either reduced and somewhat fleshy (*Arctotipula* and some *Lunatipula*) or, usually, elongate and slender, the margins quite smooth; male hypopygium without a tergal saucer and only in rare instances divided by pale membrane; basistyle not or only rarely (*Oreomyza*) produced at apex into an acute spine; claws (male) usually with a basal tooth.. 12.
12. Male hypopygium with sclerites fused into a continuous ring; region of tergite almost invariably produced into a median simple or bifid lobe that is set with microscopic spicules; claws (male) toothed.... 13.
    Male hypopygium with ninth tergite and sternite separated by a suture or by pale membrane; region of tergite not produced, usually emarginate or notched; claws (male) toothed or simple........ 15.

13. Wings with m-cu usually close to fork of M; wings usually with a longitudinally striped or vittate pattern, but without a darkened cloud in cell Cu; squama naked .... 8. *Yamatotipula.*
    Wings with m-cu at or close to midlength of cell 1st M_2; wings rarely striped longitudinally (in a few *Acutipula*), if so, with a darkened cloud at near midlength of cell Cu; some species with a costal darkening (*Tipula*); squama usually with setæ (in local fauna) .... 14.
14. Outer veins of wing with trichia; costal border of wing darkened (many *Tipula*); no dark spot at near midlength of cell Cu.. 7. *Tipula.*
    Wings with outer veins glabrous or nearly so; no costal darkening; where suffused, with a dark spot at near midlength of cell Cu. 9. *Acutipula.*
15. Wing veins almost without trichia, there being none on M or its branches; squama naked; sternopleurite and meron normally with setæ; claws simple .... 13. *Arctotipula.*
    Wing veins with evident trichia; squama naked or with a group of setæ; sternopleurite and meron glabrous; claws (male) toothed (in all local species, with the exception of a small number of *Oreomyza*). 16.
16. Squama naked .... 17.
    Squama with a group of setæ .... 18.
17. Rs very short, only a little longer than r-m and not exceeding two-thirds the length of m-cu; R_{1+2} atrophied; m-cu some distance before fork of M_{3+4}, usually at near midlength .... 11. *Papuatipula.*
    Rs elongate, subequal to or longer than m-cu; R_{1+2} usually preserved, more rarely atrophied; m-cu at or close to fork of M_{3+4}. 15. *Oreomyza.*
18. Male hypopygium with the outer dististyle very large, equalling in size or exceeding the inner style; large species with marmorate wings; ovipositor with elongate valves, their margins smooth. 3. *Sinotipula.*
    Male hypopygium with the outer dististyle small, cylindrical to depressed clavate; medium-sized species, usually with the wings plain or only weakly patterned; large species with marmorate wings (*marmoratipennis* group), the ovipositor with weak fleshy cerci. 16. *Lunatipula.*

Species of Tipula not definitely assigned to subgenera (in parenthesis, a mere opinion of possible location for certain species is given).

1. *blastoptera* Alexander.
2. *brunnicosta* Brunetti. (*Lunatipula* or *Acutipula.*)
3. *conjuncta* Alexander. (*Tipula* or *Oreomyza.*)
4. *filicornis* Brunetti, *lackschewitziana* Alexander, *mitocera* Alexander, and probably *pullimargo* Edwards, all appear allied. (*Acutipula.*)
5. *flavicosta* Alexander. (*Schummelia* or *Indotipula.*)
6. *flavothorax* Brunetti. (*Indotipula* or *Oreomyza.*)
7. *formosicola* Alexander. (Looks like *Yamatotipula* or *Acutipula,* but male antenna very remarkable.)

8. *gressitti* Alexander.
9. *halteroptera* Edwards.
10. *hingstoni* Edwards.
11. *ligulifera* Alexander. (*Oreomyza* or *Yamatotipula.*)
12. *nigrocostata* Alexander and *sakaguchiana* Alexander. (*Yamatotipula* or *Oreomyza.*)
13. *nigrinervis* Edwards and *tjibodensis* Alexander.
14. *pluto* Brunetti. (Not *Formotipula.*)
15. *xanthomelæna* Edwards. (Probably not *Schummelia*, authority Edwards.)

Besides the above, a few species are known to me only from insufficient descriptions and I cannot place them at this time.

Species of Tipula known only from insufficient descriptions.

1. *flavescens* Brunetti. (*Indotipula.*)
2. *japonica* Loew.
3. *inordinans* Walker.
4. *parva* Loew. (*Schummelia.*)
5. *perelegans* Alexander (*elegans* Brunetti, preoccupied). (*Vestiplex* or *Oreomyza.*)
6. *schummeli* Brunetti (*longicornis* Doleschall, preoccupied).
7. *tropica* de Meijere.

Tipula (*Tipulina*) *breviceps* Motschulsky (Amur) evidently belongs in the subfamily Limoniinæ, but is unrecognizable.

The following species from this faunal area, described in the genus *Tipula*, pertain to the allied genus *Ctenacroscelis* Enderlein.

Species described in Tipula that belong in Ctenacroscelis.

borneensis Brunetti (*pallida* Walker, preoccupied).
brobdignagia Westwood.
carmichaeli Brunetti.
cinerea Brunetti. (very possibly).
congruens Walker.
dives Brunetti.
flava Brunetti.
flavoides Brunetti.
fulvolateralis Brunetti.
fumipennis Brunetti.
infindens Walker.
majestica Brunetti.
mikado Westwood.
monochroa Wiedemann.
novæ-guineæ de Meijere.
ochripes Brunetti.
ornatithorax Brunetti.
pilosula van der Wulp.
præpotens Wiedemann.
punctifrons Rondani.
serricornis Brunetti.
umbrina Wiedemann.

1. Subgenus BRITHURA Edwards

Brithura Edwards, Ann. & Mag. Nat. Hist. VIII 18 (1916) 262–263.
Tipula (*Brithura*) Edwards, Ann. & Mag. Nat. Hist. X 8 (1931) 76.
Tipula (*Brithura*) Edwards, Stylops 1 (1932) 240.

Type.—*Tipula imperfecta* Brunetti (as *Brithura conifrons* Edwards). (Eastern Palæarctic.)

Body stature stout, powerfully constructed, especially the abdomen.

Antennæ 13-segmented, relatively short in both sexes; flagellar segments with verticils of unusual length, these being three to five in number, all basal, two dorsal in position; terminal flagellar segment pointed at tip, about one-third the length of the penultimate. Frontal prolongation of head moderate in length; nasus distinct, simple. Anterior vertex produced into a simple, unusually slender tubercle. Ventral genæ with long coarse setæ.

No setæ on anepisternum; dorsal sternopleurite with many (*argyrospila* and *nymphica*), few (*sancta*), or no delicate setæ (some, *sancta, fracticosta, fractistigma,* and *imperfecta*). Coxæ with abundant long coarse setæ. Pleurotergal tubercle large and conspicuous, with dense plushlike pubescence on dorsal surface. Legs relatively stout; basitarsi shorter than tibiæ; tibial spur formula 1–1–2; claws (male) with small subbasal tooth. Wings with the costal region opposite the stigma often incrassated (especially in males), more or less arched, reaching its greatest development in males of *fracticosta* and *fractistigma* where the region is enlarged and broken by a double fracture that incloses a sharp tooth (Plate 1, fig. 2); posterior border of wing, opposite termination of vein Cu_1, shallowly emarginate. Squama with numerous setæ; veins beyond cord almost without trichia, there being a complete series only on R_{4+5}; more rarely with scattered trichia or incomplete series on M_{1+2}. Venation: Sc_1 present in males, weak or entirely lacking in most females, even in species (as *fractistigma*) where it is most powerfully developed in male; Rs strongly arcuated, subequal in length to m-cu; r-m variable in length, in cases short to completely obliterated by fusion of veins R_{4+5} and M_{1+2}; cell 1st M_2 pentagonal to high subrectangular; m-cu long, at fork of M_{3+4} or shortly before this fork (Plate 1, figs. 1, 2).

Male hypopygium (Plate 2, figs. 25, 26) large, the tergite entirely separated from the sternite; basistyle small and very narrow, almost completely fused with sternite. Ninth tergite with caudal margin notched. Ninth sternite strongly produced ventrad into a median carina or tubercle. Dististyle complex, the outer arm terminating in an acute spine that is directed caudad or dorsad, longest and most conspicuous in *nymphica* (among the species where the male sex is known). Ovipositor

with cerci long and straight, smooth-margined; hypovalvæ extending to shortly beyond midlength of cerci.

Figures of venation and male hypopygia of the various species include the following:

crassa EDWARDS, Ann. & Mag. Nat. Hist. VIII 18 (1916) pl. 12, fig. 12.
fractistigma ALEXANDER, Ann. & Mag. Nat. Hist. IX 15 (1925) 387.
imperfecta BRUNETTI (as *conifrons* Edwards), Ann. & Mag. Nat. Hist. VIII 18 (1916) pl. 12, figs. 10, 11; ALEXANDER, Philip. Journ. Sci. 40 (1929) pl. 1, fig. 2.
nymphica ALEXANDER, Proc. U. S. Nat. Mus. 72 art. 2 (1927) fig. 1.
sancta ALEXANDER, Philip. Journ. Sci. 40 (1929) pl. 1, fig. 1.

The known species are all from eastern Asia, ranging from Formosa and eastern China to western China and the Himalayan region. Present information seems to indicate that the adult flies appear in late summer and autumn.

Species of the subgenus Brithura.

1. PALÆARCTIC EASTERN ASIA

imperfecta Brunetti (*conifrons* Edwards.)
sancta Alexander.

2. PALÆARCTIC CENTRAL ASIA

argyrospila sp. nov.
crassa Edwards (*gravelyi* Brunetti).
fractistigma Alexander.
imperfecta Brunetti (see 1).
nymphica Alexander.
sancta Alexander (see 1).

TIPULA (BRITHURA) ARGYROSPILA sp. nov. Plate 1, fig. 1.

Allied to *nymphica*; size very large (female, length over 40 millimeters); antennal flagellum light yellow; flagellar segments each with five verticils; tip of vertical tubercle polished yellow; pleurotergal tubercle with dorsal surface silvery; femora yellow, the tips conspicuously black; wings pale yellow, variegated by light and darker brown; prearcular region conspicuously pale yellow; vein Sc_1 atrophied; abdominal tergites deep orange, the outer lateral angles of the segments not brightened; sternites darker brown; ovipositor with shield deep red.

Female.—Length, about 43 to 45 millimeters; wing, 30 to 31.

Frontal prolongation of head dark reddish brown. Antennæ with scape dark brown; pedicel reddish brown; flagellum light yellow; flagellar segments each with five verticils. Head dark brown, the front and orbits narrowly paler; extreme point of vertical tubercle polished yellow.

Mesonotal præscutum and scutum rich cinnamon-brown, the mediotergite darker. Pleura chiefly dark brown, variegated by the conspicuous silvery dorsal surface of the pleurotergal tubercle; dorsopleural membrane broadly yellow. Legs with the femora yellow, the tips conspicuously black; tibiæ yellow, the tips rather narrowly infuscated; tarsi yellowish brown. Wings (Plate 1, fig. 1) pale yellow, variegated by light and darker brown; prearcular region conspicuously pale yellow; cells C and Sc more brownish yellow; stigma orange-yellow, surrounded by a yellow suffusion extending back to cell 1st M_2; wing tip and anal cell almost uniformly darkened, only sparsely variegated by yellow spots; outer medial field very pale, the color involving vein M_3; dark spots at origin of Rs, in cell Cu and at arculus small but conspicuous. Venation: Sc_1 atrophied; R_2 punctiform; cell 1st M_2 pentagonal, the outer end somewhat pointed; m-cu at fork of M_{3+4}.

Abdominal tergites deep orange, the posterior borders of outer segments narrowly pale; sternites darked brown. Ovipositor with the valves and shield deep red; hypovalvæ dark.

Habitat.—China (Szechwan).

Holotype, female, Fu-Lin, altitude 3,800 to 8,200 feet, 1928 (*Graham*). Paratopotype, female.

This fly is similar to the much smaller *Tipula* (*Brithura*) *nymphica* (Alexander), which must be considered as being its nearest ally. The characters available for separating the various Chinese species of *Brithura* are indicated in the accompanying key.

Key to the Chinese species of Brithura.

1. Vein Sc_1 lacking (in most females) .... 2.
   Vein Sc_1 present (chiefly in males) .... 4.
2. Femora darkened, with a yellow subterminal ring...... *sancta* Alexander.
   Femora yellow, the tips conspicuously blackened........ 3.
3. Vertical tubercle uniformly darkened; size medium (wing, female, less than 25 millimeters); outer lateral angles of basal abdominal tergites pale .... *nymphica* Alexander.
   Tip of vertical tubercle polished, light yellow; size very large (wing, female, about 30 millimeters); tergites uniformly orange, the outer lateral angles not pale........ *argyrospila* sp. nov.
4. Femora unmarked or only with a faintly darker subterminal ring. *imperfecta* Brunetti.
   Femora with the tips broadly and conspicuously blackened........ 5.
5. Wings (male) with costal border opposite stigma broken and toothed (Plate 1, fig. 2) .... 6.
   Wings with costal border unbroken in either sex (Plate 1, fig. 1)........ 7.

6. Pleura dark brown, unvariegated except by the pale dorsal surface of the pleurotergal tubercle; antennal flagellum brownish yellow; male hypopygium with the spine of dististyle large and conspicuous. *fracticosta* sp. nov.

   Pleura reddish brown, variegated with silvery, additional to the pale pleurotergal tubercle; antennal flagellum uniformly dark brown; male hypopygium with outer spine of dististyle small and weak. *fractistigma* Alexander.

7. Abdominal tergites reddish brown; femora yellow, the tips black. *nymphica* Alexander.

   Abdominal tergites brownish black; femora brown, the tips black, preceded by a yellow subterminal ring.................................. *sancta* Alexander.

TIPULA (BRITHURA) IMPERFECTA Brunetti.

Tipula imperfecta BRUNETTI, Rec. Indian Mus. 9 (1913) 260–261.
Brithura conifrons EDWARDS, Ann. & Mag. Nat. Hist. VIII 18 (1916) 262–263.

The types of the above names were from the eastern Himalayas and Formosa, respectively. The species had not been recorded previously from any intermediate station.

Kwanhsien, Szechwan, altitude 3,000 feet, August 16, 1930 (*Franck*). Mount Omei, Szechwan, altitude 5,500 to 10,800 feet, August 16 to 20, 1934 (*Graham*).

TIPULA (BRITHURA) FRACTICOSTA sp. nov. Plate 1, fig. 2; Plate 2, fig. 25.

Allied to *fractistigma;* antennal flagellum brownish yellow to pale brown; thoracic pleura dark brown, scarcely variegated except for the silvery dorsal surface of the pleurotergal tubercle; legs dark, the femora with a yellow subterminal ring; wings (male) with the costa broken opposite the stigma; male hypopygium with a dense brush of setæ on basistyle; spine of dististyle long and conspicuous.

Male.—Length, about 28 to 30 millimeters; wing, 22 to 24.

Frontal prolongation of head dark brown; nasus stout but distinct; palpi brownish black. Antennæ with scape and pedicel light brown, the flagellum more brownish yellow to pale brown. Head dark brown, the sides of the vertical tubercle and posterior orbits paler.

Pronotum and mesonotum dark brown, the pronotal scutellum obscure yellow. Pleura almost uniformly dark brown; dorsopleural membrane obscure yellow. Pleurotergal tubercle with dense silvery pubescence on dorsal surface. Halteres dark brown, the apices of the knobs pale. Legs with the coxæ and trochanters dark brown to almost black; femora narrowly obscure yellow at base, thence strongly blackened, the tip black, preceded by a subequal yellow ring; tibia brown, the base nar-

rowly pale, the tip narrowly and weakly darkened; tarsi brownish black. Wings (Plate 1, fig. 2) strongly yellow, the prearcular and anterior portions clearer yellow; stigma and surrounding portions strongly saturated; a sparse dark and paler brown pattern; outer halves of cells R_2 and R_3 darkened; bases of all outer medial cells restrictedly infuscated; a broad seam on m-cu and adjoining portions of vein Cu_1; bases of cells R and M darkened; weak longitudinal clouds in cells R and M; veins yellow. Costal border of wing thickened, strongly bulging opposite stigma and here distinctly broken and interrupted by a sharp spur. Venation: Sc_1 strong, much longer than Sc_2; r-m obliterated by fusion of veins R_{4+5} and M_{1+2}, the distal section of the latter vein strongly sinuous; cell 1st M_2 unusually high, subrectangular in outline, the longest elements being the basal section of M_{1+2} and m; vein M_4 strongly arcuated.

Abdomen dark brown, the outer lateral angles of the segments restrictedly pale; hypopygium dark. Male hypopygium (Plate 2, fig. 25) with the caudal border of tergite, *9t*, deeply emarginate medially, the base of the notch with setæ, the lateral lobes with more abundant and conspicuous copper-colored setæ. Basistyle much reduced, with a dense brush of burnished setæ. Dististyle, *d*, as figured; outer spine large, the apical blade narrow. Tubercle of the ventrally produced ninth sternite, *9s*, moderately developed.

Habitat.—China (Szechwan).

Holotype, male, Lin-Ngai-Si, near Kwanhsien, altitude 3,500 feet, September 20, 1930 (*Graham*). Paratype, male, Ginfŭ-Shan, District Nanchŭan, August, 1929–1931 (*Friedrich*).

I am referring the Nanchŭan specimen here with some doubt, as the pleura is different in color from that of the type, the dorsal sternopleurite, ventral pteropleurite, and most of the meron being pruinose with gray, contrasting with the remainder of pleura. The relationship with *fractistigma* (dististyle, Plate 2, fig. 26, *d*) is shown by the key provided at this time.

2. Subgenus NIPPOTIPULA Matsumura

Nippotipula MATSUMURA, Thousand Ins. Japan, Add. 2 (1916) 457–458.

Tipula (*Nippotipula*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 77.

Tipula (*Nippotipula*) EDWARDS, Stylops 1 (1932) 238.

Type.—*Tipula coquilletti* Enderlein (as *Nippotipula nubifera* Coquillett by Matsumura). (Eastern Palæarctic.)

Antennæ 13-segmented, relatively short in both sexes; verticils exceeding the segments in length; terminal flagellar segment more than one-half as long as the penultimate. Vertical tubercle low and poorly developed.

Scutal lobes each with two darkened areas that are ringed with pale color. Setæ on propleura and sides of pronotal scutellum, as well as on the sternopleurite and more sparsely on anepisternum. Mesonotal interspaces with relatively abundant setæ that are long and conspicuous, especially on the scutellum and mediotergite. Pleurotergal tubercle moderately developed. Tibial spur formula 1–2–2; claws (male) toothed. Wings with Rs very long, fully twice m-cu, the latter close to midlength of cell 1st M_2 and almost always uniting with M_{3+4} some distance before its fork; in rarer cases, m-cu close to fork of M_{3+4} (*phædina*); Rs in direct alignment with R_{4+5}, the basal deflection of the latter lacking. Squama with a group of setæ; M and branches naked or with sparse trichia.

Abdomen long to very long especially in *coquilletti* and *sinica*. Male hypopygium with suture between ninth tergite and sternite complete; basistyle cut off from sternite only by ventral suture. Outer dististyle very large and depressed; inner style unusually small. Eighth sternite produced caudad into a profoundly bifid median lobe. Ovipositor with smooth cerci; hypovalvæ well developed.

Species of the subgenus Nippotipula.

1. PALÆARCTIC EASTERN ASIA

coquilletti Enderlein (*nubifera* Coquillett, preoccupied).

sinica sp. nov.

2. PALÆARCTIC CENTRAL ASIA

phædina Alexander.

pulcherrima Brunetti.

sinica sp. nov. (see 1).

susurrans Edwards.

3. ORIENTAL EASTERN ASIA

anastomosa Edwards.

xanthostigma Edwards.

TIPULA (NIPPOTIPULA) SINICA sp. nov. Plate 1, fig. 3; Plate 2, fig. 27.

Very closely allied to *coquilletti*, differing in the usually smaller size, more-slender build, less extensively darkened median præscutal stripe, and the chiefly black legs, especially the fore pair.

Male.—Length, 30 to 33 millimeters; wing, 21 to 23; abdomen alone, 22 to 23.

Female.—Length, 35 to 36 millimeters; wing, 22 to 23; abdomen alone, 28 to 29.

Frontal prolongation of head brown, light gray pruinose above; nasus distinct; palpi brownish black, the terminal segment beyond base somewhat paler. Antennæ with basal segment brown; pedicel yellow; basal flagellar segment brownish yellow, the succeeding segments dark brown with their basal enlargements a trifle darker; longest verticils exceeding the segments. Head light gray, the genæ darker.

Pronotum whitish gray, slightly darker medially. Mesonotal præscutum whitish gray, with three stripes, the median stripe chiefly dark gray, the outer borders conspicuously velvety black on cephalic half or less; lateral stripes chiefly velvety black, paling to gray behind; humeral region immediately before the lateral stripes more or less darkened; each scutal lobe with two velvety black spots that are narrowly bordered by light gray, the median region of the scutum slightly darker gray; scutellum brownish gray, the sunken parascutella darker; mediotergite gray, variegated laterally and behind with darker, the latter pattern consisting of two circular areas; in cases a more or less distinct median dark line on scutellum and mediotergite. Pleura silvery gray with a broad brown dorsal stripe extending from the cervical region to the pleurotergite, where it becomes a little paler; extreme ventral sternopleurite and dorsal meron darkened. Halteres dark brown, the base of stem narrowly pale. Legs with the fore coxæ brownish gray, narrowly dark brown at base middle coxæ gray, narrowly darkened at posterior border; posterior coxæ chiefly dark brown, the outer end gray; trochanters chiefly dark brown; legs chiefly black, especially the fore pair; femoral bases restrictedly pale, broadest and most conspicuous on posterior legs. Wings (Plate 1, fig. 3) with the pattern almost as in *coquilletti*, differing only in slight details; ground color whitish, with darker washes and two major clouds, the latter at origin of Rs and in the stigmal region; outer radial field less strongly suffused, especially in outer end of cell R_3; a series of dark marginal spots at ends of all outer longitudinal veins; veins brown, paler in costal field. Venation: Rs shorter than in *coquilletti*.

Abdomen chiefly yellow; first tergite dark with a median yellow line; succeeding tergites with the margins pale, the subcaudal borders very narrowly blackened; a black median tergal

stripe begins on the third segment, becoming broader and more diffuse behind; lateral borders of tergites narrowly grayish; hypopygium more uniformly darkened. Male hypopygium (Plate 2, fig. 27) with the tergite, *9t*, separated from the sternite, *9s*, by a suture; basistyle chiefly fused with sternite, represented by a weak ventral suture, the posterior end of style produced into a short broad truncated lobe. Ninth tergite, *9t*, greatly arched, the caudal margin with two blackened lobes that are set with black spinulæ. Eighth sternite, *8s*, produced into a broadly flattened, shovellike lobe that is profoundly split, each lateral lobe relatively broad.

Habitat.—China.

Holotype, male, Hills near Ning-po, halfway to Nimrod Sound, Che kiang, May 1, 1925 (*Suenson*). Allotopotype, female. Paratopotype, male. Paratypes, males and females, Kwanhsien, Szechwan, 2,000 to 4,000 feet, May 8 to 28, 1930 (*Graham*); females, Chengtu, Szechwan, altitude 1,700 feet, April 1 to 10, 1933 (*Graham*).

While the present fly is closely allied to *Tipula* (*Nippotipula*) *coquilletti* Enderlein, there seems to be little question of its distinctness.

3. Subgenus SINOTIPULA novum

Type.—*Tipula exquisita* sp. nov. (Eastern Palæarctic.)

Antennæ 13-segmented; verticils very long and conspicuous, fully one-half longer than the segments; terminal segment about one-half as long as the penultimate. Frontal prolongation of head long; nasus distinct. Vertical tubercle low and merely protuberant.

No setæ on mesopleura. Coxæ with abundant long setæ. Pleurotergal tubercle not or scarcely evident. Legs relatively long and slender; basitarsi a little shorter than the tibiæ; tibial spur formula 1–1–2; claws (male) with subbasal tooth. Squama and veins with trichia. Wings with outer section of vein R_1 unusually long, much longer than the free tip of Sc_2; R_{1+2} entire; vein R_3 more or less sinuous, somewhat constricting cell R_3 at near midlength; basal section of R_{4+5} long and distinct; Rs long to very long, from one and one-half to more than two times as long as m-cu; m-cu at or very close to fork of M_{3+4}. unusually long, so cell M_4 is markedly wider at base.

Male hypopygium (Plate 2, fig. 28–31) with tergite and sternite separated by a suture. Tergite large and tumid, often

with two rounded lobes on caudal portion; in some species (including the subgenotype) with complex sclerotized armature on ventral surface. Outer dististyle very large, equaling or exceeding in area and complexity the relatively small inner style. Ovipositor with cerci long and relatively slender, the margins smooth.

Points of contact.—The subgenera most apt to be confused are *Brithura*, *Nippotipula*, and *Lunatipula*, all of which have similar groups of setæ on the squamæ and include members of large size and of showy coloration. *Brithura* is readily told by the slender conical vertical tubercle; *Nippotipula* by the lack of the basal section of R_{4+5} and the position of m-cu far before the fork of M_{3+4}. Some of the groups that I have referred to *Lunatipula*, especially the *marmoratipennis* group, bear a general resemblance to the present aggregation of species yet are quite distinct in the structure of the ovipositor and other characters.

Species of the subgenus Sinotipula.

2. PALÆARCTIC CENTRAL ASIA

bodpa Edwards.
brunettiana Alexander (*splendens* Brunetti, preoccupied).
cranbrooki Edwards.
exquisita sp. nov.
gloriosa sp. nov.
gregoryi Edwards.
griseipennis Brunetti.
hobsoni Edwards.
persplendens sp. nov.
sindensis Alexander.
tessellatipennis Brunetti.
thibetana de Meijere.
trilobata Edwards.
waltoni Edwards.
wardi Edwards.

I had earlier called all of these the *thibetana* group, but it now seems that *exquisita*, *gregoryi*, *hobsoni*, and *waltoni* may well be separated as a distinct group, the *gregoryi* group, based chiefly on conspicuous modifications of the ninth sternite of the male hypopygium.

TIPULA (SINOTIPULA) EXQUISITA sp. nov. Plate 1, fig. 4; Plate 2, fig. 28.

Belongs to the *gregoryi* group, allied to *gregoryi;* head above light gray; wings pale brown, variegated by darker brown and cream-colored areas; prearcular region chiefly pale, the arcular transverse band ill-defined; male hypopygium with two pairs of lobes on ninth sternite, projecting caudad, the more dorsal pair clothed with long yellow setæ.

Male.—Length, 19 to 22 millimeters; wing, 22 to 25.

Female.—Length, 22 to 24 millimeters; wing, 24 to 26.

Frontal prolongation of head reddish brown, a little darker on sides; nasus elongate; palpi dark brown, terminal segment black. Antennæ with scape and pedicel yellow; flagellum brownish black; longest verticils a little exceeding the segments. Head above light gray, with vague indications of a darker median vitta; genæ darker; a darkened spot above each antennal fossa, as in *gregoryi*.

Pronotum dark medially, broadly yellow on sides. Mesonotal præscutum brownish yellow with four slightly indicated brighter brown stripes, the intermediate pair scarcely separated by a median vitta; humeral and lateral margins a little darkened; scutal lobes brown; scutellum brownish gray; mediotergite clearer gray. Pleura dark brown, variegated with silvery on dorsal sternopleurite and meron; dorsopleural region light yellow. Halteres with stem obscure yellow, brighter at base; knobs darkened basally, the tips paler. Legs with the coxæ dark gray; trochanters yellowish brown; femora obscure yellow, the tips black; tibiæ and basitarsi yellow, the tips narrowly darkened; remainder of tarsi black. Wings (Plate 1, fig. 4) with a pale brown tinge, variegated by darker brown and sparse cream-colored areas, the ground color much paler than in *gregoryi*, but the pattern arranged much the same; arcular pale band incomplete, best indicated in cell 2d A, in the arcular region more diffuse due to a general paling of the prearcular field. Wings shorter and broader than in *gregoryi;* cell 1st M_2 proportionately smaller.

Abdomen (male) with basal six segments reddish yellow, without distinct markings; outer abdominal segments black. In female the tergites striped laterally with dark brown. Male hypopygium (Plate 2, fig. 28) with the tergite, 9*t*, having the caudal border weakly emarginate, clothed with abundant coarse setæ; on ventral surface of tergite (as figured) a transversely quadrate sclerotized plate that is conspicuously armed with large spines at each angle of the plate; dorsal border of this tergal plate with three smaller, slenderer spines. Dististyle, *d*, complex, as figured. From the mesal-caudal portion of the sternite, 9*s*, protrude two pairs of conspicuous appendages; the more dorsal pair are fleshy lobes that are densely tufted with yellow setæ; the more-ventral appendages appear as compressed blades, their margins with parallel striæ. Ovipositor with short, stout cerci.

Habitat.—China (Szechwan-Tibet border).

Holotype, male, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*). Allotype, female, Yu-Long-Gong, altitude, 14,000 feet, August 14, 1930 (*Graham*). Paratopotypes, 4 males. Paratypes, 1 male, 1 female, Zya-Ha Pass, altitude 14,000 to 17,000 feet, July 25 to 27, 1930; 1 male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930; 1 male, near Yien-Long-Shien, altitude 13,000 to 15,000 feet, August 3 to 6, 1930 (*Graham*).

The nearest allies of the present fly are *Tipula* (*Sinotipula*) *gregoryi* Edwards (Yunnan, Szechwan) and *T.* (*S.*) *waltoni* Edwards (Tibet), both of which differ especially in the details of coloration of the body and wings.

TIPULA (SINOTIPULA) GLORIOSA sp. nov. Plate 1, fig. 5; Plate 2, figs. 29 and 30.

Belongs to the *thibetana* group; allied to *trilobata;* mesonotum brownish yellow, with four conspicuous brown stripes; lateral margins of præscutum further darkened; antennal flagellum black; femora brownish yellow, the tips very narrowly to scarcely darkened; wings brown, tessellated with yellow; male hypopygium with the outer dististyle larger than the inner.

Male.—Length, about 18 millimeters; wing, 20.

Frontal prolongation of head brownish gray; nasus conspicuous; palpi dark brown, in the paratype female with the intermediate segments conspicuously light yellow. Antennæ of moderate length to short, in male, if bent backward, not quite reaching the wing root; scape brownish yellow; pedicel and base of first flagellar segment yellowish brown; remainder of flagellum black, the basal enlargements of the segments a little more protuberant on outer face so the flagellar segments appear slightly irregular in their alignment. Head brownish gray, clearer gray on front and anterior vertex; a narrow black vitta from summit of anterior vertex to the occiput.

Pronotal scutellum chiefly black, obscure yellow behind. Mesonotal præscutum with the ground color brownish yellow, with four conspicuous brown stripes, the intermediate pair approximated or narrowly contiguous at extreme cephalic end; lateral portions of præscutum before suture narrowly black, behind the suture more extensively dark brown; humeral region between the lateral and intermediate stripes washed with dusky; scutum

grayish yellow, each lobe variegated by a large brown area; scutellum light gray, with a median brown vitta, more evident in female; mediotergite grayish brown. Pleura chiefly pale, with brown longitudinal areas, including a dorsal stripe; dorsopleural region conspicuously yellow. Halteres yellow, the base of each knob dusky. Legs with the coxæ brown; trochanters yellowish brown; femora, tibiæ, and basitarsi brownish yellow, the extreme tips blackened; remainder of tarsi black. Wings (Plate 1, fig. 5) rather dark brown, conspicuously variegated with yellow, more contrasted in female than in male; prearcular region chiefly infumed; cell C brownish yellow, cell Sc clear yellow; the yellow discal areas appear as zigzag crossbands over the basal cells of wing, beyond the cord appearing as an incomplete crossband beyond stigma, not reaching cell 1st M_2, and as pale triangular spots in outer ends of cells R_3 to M_4, inclusive, more extensive in cell R_5 where nearly the outer end is pale; cubital and anal cells more conspicuously variegated by the zigzag areas above mentioned; a more whitish obliterative band across cord, from cell R to base of cell M_3; veins dark, more yellowish in the flavous areas. Venation: R_{1+2} preserved; R_3 arched, somewhat constricting cell R_3 at near midlength; m-cu very long, cell M_4 much wider at base than at apex.

Abdomen with basal tergite infuscated; succeeding tergites obscure yellow, beyond the second darkened sublaterally at base, the lateral borders broadly pale; sternites chiefly yellow; outer segments and hypopygium passing into black. Male hypopygium (Plate 2, fig. 29) large and rounded, without conspicuously projecting appendages; the tergite, *9t*, with two low glabrous lobes on caudal portion, the arched dorsal portion with long conspicuous black setæ. Dististyles (Plate 2, fig. 30, *od*, *id*) as shown, the inner much smaller than the outer, with a small pale appendage near its apex, the actual tip stout.

Habitat.—China (Szechwan).

Holotype, male, Wei-Chow, 65 miles northwest of Chengtu, altitude 9,000 to 12,500 feet, August 15, 1933 (*Graham*). Allotype, broken female, O-Er, 26 miles north of Li-Fan, altitude 10,800 feet, August 16, 1933 (*Graham*). Paratopotype, broken female, with holotype.

The present fly and the one next described are closely related, being apparently most nearly allied to *Tipula* (*Sinotipula*) *trilobata* Edwards among the described forms, differing conspicu-

ously in the coloration of the thorax and abdomen, and in genitalic structures.

TIPULA (SINOTIPULA) PERSPLENDENS sp. nov. Plate 2, fig. 31.

Belongs to the *thibetana* group; allied to *gloriosa;* mesonotal præscutum obscure yellow, with four reddish brown stripes that are very narrowly bordered by darker; antennal flagellum brownish black; femora yellow, the tips very narrowly and insensibly darkened; wings pale brown, variegated and tessellated with pale yellow and darker brown areas; outer medial cells with centers washed with pale brown; basal abdominal segments reddish brown, the outer segments darkened; male hypopygium with the inner dististyle bifid at apex, the beak slender.

Male.—Length, about 25 millimeters; wing, 27.

Female.—Length, about 27 millimeters; wing, 27.

Frontal prolongation of head elongate, brown, the dorsum light gray pruinose; nasus distinct; palpi brown, the elongate outer segment brownish black. Antennæ relatively short, in male, if bent backward not quite attaining the wing root; scape yellow; pedicel and first flagellar segment brownish yellow; remainder of organ brownish black. Head light gray with a continuous, dark brown, median stripe from summit of vertex to occiput.

Pronotum dark brown medially, paler on sides. Mesonotal præscutum obscure yellow, with four reddish brown stripes that are very narrowly and irregularly bordered by brown, more evident on the lateral stripes and cephalic portions of the intermediate stripes; a dusky line across the humeral region, from the intermediate stripe caudad; lateral border of sclerite before the suture strongly darkened; median region of præscutum adjoining the suture narrowly bordered by dark brown; scutal lobes reddish brown, paler medially and narrowly silvery adjoining the suture, with a dusky mark on mesal edge behind; scutellum and mediotergite gray laterally, brown medially. Pleura pale, conspicuously variegated by dark brown, including a dorsal stripe extending from the cervical region across propleura, ventral anepisternum, and ventral pteropleurite; ventral sternopleurite and meron darkened; dorsopleural region light yellow. Halteres yellow, the knobs infuscated, the apex a little paler. Legs with the coxæ gray, narrowly darkened at base; trochanters brownish yellow; femora and tibiæ yellow, the tips very narrowly and insensibly darkened; tarsi black, the proximal

end of basitarsus brightened. Wings with the ground color rather pale brown in both sexes, variegated by extensive pale yellow areas and more restricted darker brown markings; the darker brown areas include a relatively small postarcular darkening that is more extensive in cell Cu; a very small spot at origin of Rs, and the stigmal darkening; the ground areas of paler brown appear as extensive zigzag clouds across the basal half of wing, restricting the yellow to narrow lines; beyond the cord the centers of the outer medial cells are washed with very pale brown, at margin inclosing a clear yellow spot; dark area in cell R_5 much restricted; poststigmal yellow area extensive; veins pale brown, C, Sc, R, and outer half of Cu clearer yellow. Venation: m-cu very long.

Basal three abdominal tergites reddish brown, the succeeding segments somewhat darker, in male more or less pruinose, in female with caudal borders of the segments narrowly yellow; basal sternites reddish brown, the outer segments darker. Male hypopygium in general somewhat similar to that of *gloriosa;* caudal margin of tergite terminating in two low rounded lobes, the notch between small and circular; tergal lobes with setæ almost to outer ends; dorsal posterior portion of tergite with numerous setæ. Diststyles (Plate 2, fig. 31, *od*, *id*) as figured; inner style at apex split into two slender lobes, the darker-colored one being the usual beak; outer style very obtuse in its outlines, on its cephalic margin at near midlength with a flattened, sclerotized plate.

Habitat.—China (Szechwan-Tibet border).

Holotype, male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*). Allotype, female, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*).

The nearest ally of the present fly is *Tipula* (*Sinotipula*) *gloriosa* sp. nov., which is readily told by the different wing pattern and structure of the male hypopygium.

4. Subgenus TRICHOTIPULA Alexander

Tipula (*Trichotipula*) ALEXANDER, Proc. Acad. Nat. Sci. Philadelphia **67** (1915) 468.

Tipula (*Cinctotipula*) ALEXANDER, Proc. Acad. Nat. Sci. Philadelphia **67** (1915) 469.

Tipula (*Odontotipula*) ALEXANDER, Cornell Univ. Agr. Exp. Sta. Mem. **38** (1919) 943.

Type.—Tipula oropezoides Johnson. (Eastern Nearctic.)

Antennæ short to elongate (in male); verticils present but usualy shorter than the segments. Frontal prolongation of head short to very short, much as in *Dolichopeza;* nasus long and slender.

Halteres elongate. Legs long and slender; tibial spur formula 1–2–2; claws (male) with basal tooth. Squama naked; all longitudinal veins with trichia, almost, if not quite, to wing base; abundant trichia in outer cells of wing, most numerous in *polytricha* where virtually the entire wing surface is covered. Venation: R_{1+2} entire; Rs short, subequal to m-cu; m-cu on M_{3+4} shortly beyond fork of M, the former thus being short to almost lacking; cell M_4 deep, widened at proximal end, m-cu being oblique to very oblique.

Male hypopygium of simple construction; posterior margin of ninth sternite more or less produced caudad into a fleshy lobe. Ovipositor with cerci sclerotized, compressed-flattened, the tips obtuse, considerably exceeding the hypovalvæ.

Species of the subgenus Trichotipula.

1. Palæarctic Eastern Asia. *haplotricha* Alexander.
2. Palæarctic Central Asia. *polytricha* Alexander.

5. Subgenus SCHUMMELIA Edwards

Tipula (Schummelia) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 80–81.

Type.—Tipula variicornis Schummel. (Northern Palæarctic.)

Antennæ (male) often elongate; verticils long, subequal to or exceeding the segments except in the species with elongate antennæ; terminal segment reduced to a thimble-shaped structure. Frontal prolongation of head short to very short; nasus conspicuous.

Mesopleura glabrous. Tibial spur formula 1–2–2; claws (male) with basal tooth. Squama with abundant setæ; all veins beyond cord with numerous macrotrichia; some species (*macrotrichiata* group) with sparse macrotrichia in outer cells. Venation: R_{1+2} entire; Rs relatively short, subequal to the long m-cu; cell M_4 deep and markedly wider at base than at margin; m-cu very oblique, variable in position, often placed near base of the small or medium-sized cell 1st M_2, in other cases at near midlength of the cell, close to the fork of M_{3+4}; M_4 in direct

alignment with M_{3+4}; m often reduced in length by the approximation of veins M_{1+2} and M_3; Cu_1 without a distinct constriction or shirring at point of insertion of m-cu.

Male hypopygium with tergite and sternite separate, or fused on extreme cephalic portion only. Median region of tergite produced into a compressed blade (*variicornis* subgroup) or notched medially (*continuata* subgroup). Outer dististyle elongate but compressed. Inner dististyle a flattened blade, on cephalic margin produced into a slender beak. Eighth sternite unarmed. Ovipositor with long, straight, very slender cerci; hypovalvæ elongate, compressed, longer than the cerci.

The three groups in the local fauna have been briefly discussed in another paper.[3] The present subgenus and *Trichotipula* must be very close to the ancestral type of the genus *Dolichopeza*.

Species of the subgenus Schummelia.

1. PALÆARCTIC EASTERN ASIA

acifera Alexander.
bidenticulata Alexander.
cylindrostylata Alexander.
ecaudata Alexander.
esakiana Alexander.
imanishii Alexander.
insulicola Alexander.
i. fuscicauda Alexander.
jocosipennis Alexander.
macrotrichiata Alexander.
microcellula Alexander.
nikkoensis Alexander.
nipponensis Alexander.
querula Alexander.
rantaicola Alexander.
sparsiseta Alexander.
sparsissima Alexander.
strictiva Alexander.
variicornis Schummel.
v. latiligula Alexander.

2. PALÆARCTIC CENTRAL ASIA

angustiligula Alexander.
chumbiensis Edwards.
continuata Brunetti.
honorifica Alexander.
indifferens Alexander.
indiscreta Alexander.
nigrocellula Alexander.
sessilis Edwards (*demarcata* Brunetti, preoccupied).
xanthopleura Edwards.

3. ORIENTAL EASTERN ASIA

hampsoni Edwards.
inconspicua de Meijere.
klossi Edwards.
pendleburyi Edwards.
picticornis (Brunetti).
pumila de Meijere.
rhombica Edwards.
salakensis Alexander (*robinsoni* Edwards).
vitalisi Edwards.

[3] Alexander, Philip. Journ. Sci. 51 (1933) 374.

6. Subgenus FORMOTIPULA Matsumura

Formotipula MATSUMURA, Thousand Ins. Japan, Add. 2 (1916) 456–457.

Tipula (*Formotipula*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 77.

Type.—*Formotipula holoserica* Matsumura. (Eastern Palæarctic.)

Antennæ of moderate length, the verticils exceeding the segments. Frontal prolongation of head short; nasus short but distinct; palpi elongate.

No setæ on mesopleura; on notum sparse and erect. Tibial spur formula 1–1–2; claws (male) toothed. Squama naked; trichia of outer medial branches variable in number, sometimes much reduced, in the subgenotype relatively numerous. Venation: R_{1+2} preserved (*dikchuensis, friedrichi, holoserica, hypopygialis, luteicorporis, melanomera, melanopyga, rufizona, rufoabdominalis,* and *sciariformis*), normally lacking or more or less atrophied in the remaining species; Rs of moderate length, subequal to or much shorter than m-cu; fork of M_{3+4} close to midlength of cell 1st M_2, m-cu at or just beyond this fork; cell M_4 short and broad, m-cu being only a little shorter than the distal section of Cu_1.

Abdomen short and compact, in male with hypopygium strongly tilted upward. Male hypopygium with the tergite separated from the sternite by a suture or, in cases (as in *friedrichi*), with the suture obsolete or virtually so, the tergite being fused with the sternite. Ninth tergite either notched medially or with a more or less distinct, beaklike, median projection (*friedrichi, holoserica,* and others). In cases basistyle more or less produced at apex into a fleshy lobe that is sometimes set with spinous points. Dististyle single, usually complicated in structure. Eighth sternite unarmed. Ovipositor with both cerci and hypovalvæ greatly reduced in size, fleshy.

The included species are medium-sized to relatively large flies, with highly contrasted coloration, the thorax either velvety black or reddish orange, contrasting strongly with the opposite color elsewhere on the body. Abdomen usually bicolorous, the basal portion reddish, the apex blackened. Edwards reports some variation in the presence or absence of vein R_{1+2} in *melanomera* and possibly in other species.

Species of the subgenus Formotipula.

1. PALÆARCTIC EASTERN ASIA

holoserica Matsumura (***nigrorubra*** Riedel, ***rufomedia*** Edwards).
kiangsuensis Alexander.

2. PALÆARCTIC CENTRAL ASIA

dikchuensis Edwards.
exusta Alexander.
friedrichi sp. nov.
hypopygialis Alexander.
luteicorporis Alexander.
melanomera Walker.
obliterata Alexander.
omeicola sp. nov.
rufizona Edwards.
rufoabdominalis Alexander (*rufiventris* Brunetti, preoccupied).

3. ORIENTAL EASTERN ASIA

cinereifrons de Meijere.
dusun Edwards.
laosica Edwards.
lipophleps Edwards.
melanopyga Edwards.
sciariformis Brunetti.

Tipula pluto Brunetti (French Indo-China: Tonkin) cannot belong to *Formotipula,* as stated by Edwards (1932), because of the structure of the ovipositor.

TIPULA (FORMOTIPULA) OMEICOLA sp. nov. Plate 1, fig. 6.

Head and thorax velvety black, the præscutum with indications of four faintly gray stripes; wings strongly tinged with black; R_{1+2} entirely atrophied; cell 1st M_2 relatively large; abdomen black, with segments two to five, inclusive, orange-yellow.

Female.—Length, about 13 milimeters; wing, 14.

Entire head black; nasus short but distinct. Antennæ and palpi black.

Thorax velvety black, the præscutum with indications of four faintly gray stripes, the intermediate pair separated by a line of the ground color that is a little wider than either stripe; posterior sclerites of notum sparsely pruinose. Pleura black. Halteres and legs black throughout. Wings (Plate 1, fig. 6) strongly tinged with blackish, the oval stigma darker brown; veins dark brown. Venation: R_{1+2} entirely atrophied; cell 1st M_2 of moderate length, much larger than in *obliterata;* second section of M_{1+2} longer than the third section (petiole of cell M_1).

Abdomen with the first segment black; segments two to five, inclusive, entirely orange-yellow; remaining segments, including ovipositor, black.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 4,500 feet, August 10, 1929 (*Franck*).

The nearest ally is undoubtedly *Tipula* (*Formotipula*) *obliterata* Alexander (Szechwan-Tibet border), which is approximately similar in color, except that the fifth abdominal segment is extensively blackened. The latter species further has cell 1st M_2 unusually small, less than the petiole of cell M_1.

TIPULA (FORMOTIPULA) FRIEDRICHI sp. nov. Plate 1, fig. 7; Plate 2, fig. 32.

Head and thorax, with appendages, entirely velvety black; abdomen with first segment and outer five segments velvety black, the intermediate segments chiefly orange, the color somewhat variable, in cases with the orange color much reduced by encroachment of the black; wings strongly dimidiate, the cells before the cord strongly suffused with brown, the outer cells paling to gray; R_{1+2} entire; male hypopygium with the median region of the tergite produced into a lobe that terminates in an acute decurved point.

Male.—Length, 13 to 15 millimeters; wing, 12.5 to 14.5.

Female.—Length, 12 to 14.5 millimeters; wing, 13.5 to 16.5.

Head and appendages black. Antennæ of moderate length, in male if bent backward extending approximately to wing root.

Thorax, including the dorsopleural membrane, velvety black. Halteres and legs entirely black. Wings (Plate 1, fig. 7) conspicuously bicolorous, the cells before the cord strongly suffused with brown, beyond the cord paling to light gray; stigma somewhat darker brown; veins dark brown to black. Venation: R_{1+2} entire; R_2 long, perpendicular.

Abdomen somewhat variable in color, in the types with the basal segment and all of segments five to nine, inclusive, involving the genitalia of both sexes, black; segments two to four, inclusive, deep orange, the extreme posterolateral angles of both tergites and sternites black; in female, posterior median portion of first tergite orange. Other specimens that are undoubtedly conspecific have the orange of the tergites much reduced, in cases restricted to the second tergite; in still other cases the caudal borders of the normally orange tergites and sternites are broadly margined with black, greatly restricting the ground color.

Male hypopygium (Plate 2, fig. 32) with the tergite, *9t*, and sternite, *9s*, fused. Ninth tergite, *9t*, with the median region

of the outer portion narrowed and heavily blackened, the tip decurved to an acute point. Basistyle, *b*, produced caudad into a powerful blackened lobe, the tip obtuse, set with abundant short black spines and numerous long black setæ (in figure shown detached, so as not to hide other parts). Dististyle, *d*, somewhat polished black, at tip produced into two more or less opposed lobules that inclose a small rounded notch, the surface of style with abundant setæ. Ninth sternite, *9s*, on either side of median area with a smaller black lobe that is clothed with long black setæ.

Habitat.—China (Szechwan).

Holotype, male, Ginfŭ-Shan, District Nanchŭan, May 1929–31 (*Friedrich*); in Deutsches Entomologisches Museum. Allotopotype, female, in my collection. Paratypes, 10 males and females, mostly in poor condition, Mupin, altitude about 3,500 feet, 1929 (*Graham*).

This very distinct fly is named in honor of the collector of the type specimen. The nearest ally seems to be the subgenotype, *holoserica* (Matsumura), from which the present insect differs notably in the strongly bicolorous, somewhat dimidiate wings.

7. Subgenus TIPULA Linnæus

Tipula LINNÆUS, Systema Naturæ ed. 10 (1758) 585.
Tipula LACKSCHEWITZ, Konowia 9 (1930) 257–278, 2 pls.
Tipula (*Tipula*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 75.

Type.—*Tipula oleracea* Linnæus. (Western Palæarctic.)

Antennæ relatively short; verticils long and conspicuous, exceeding the segments in length. Frontal prolongation of head relatively long; nasus elongate.

Mesopleura glabrous, including sternopleurite (or this in cases with setæ, according to Edwards). Tibial spur formula 1–2–2; claws (male) with basal tooth. Squama naked or (more rarely with setæ; veins beyond cord with trichia. Venation: R_{1+2} entire; Rs of moderate length, from one and one-half to nearly two times the length of m-cu, the latter at or close to midlength of cell 1st M_2, somewhat closer to base in the *ultima* group.

Male hypopygium with tergite and sternite fused into a continuous ring, the suture sometimes feebly indicated posteriorly; median region of tergite produced caudad into a broadly depressed lobe (*oleracea* group) or notched medially (*luteipennis* or *ultima* group); basistyle incomplete, represented by the ven-

tral suture. Inner dististyle (*oleracea* and allies) complex, with four distinct processes, the first, or more posterior, a slender curved spine. Ovipositor with long slender cerci, the narrow tips obtuse; hypovalvæ shorter, compressed.

Species of the subgenus Tipula.

1. PALÆARCTIC EASTERN ASIA

mediolobata Alexander.
moiwana (Matsumura).
subcunctans Alexander (*czizeki* de Jong).

8. Subgenus YAMATOTIPULA Matsumura

Yamatotipula MATSUMURA, Thousand Ins. Japan, Add. 2 (1916) 461–462.
Tipula lateralis Formen-kreis, LACKSCHEWITZ, Naturforscher-Ver. Riga (new series) 15 (1923) 3–16, 33 figs.
Tipula (*Yamatotipula*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 77–78.

Type.—*Tipula nova* Walker (as *Yamatotipula nohiræ* Matsumura). (Eastern Palæarctic.)

Antennæ short (in local species) to very long; flagellar segments only feebly incised; verticils relatively small, shorter than the segments. Frontal prolongation of head moderate in length; nasus elongate.

Mesopleura glabrous. Tibial spur formula 1–1–2 or 1–2–2; claws (male) toothed. Squama naked; outer branches of M with trichia. Venation: R_{1+2} entire; Rs long, nearly if not quite twice m-cu, in extreme cases even longer; M_{3+4} short to very short, m-cu lying close to base of cell 1st M_2; second section of M_{1+2} and basal section of M_3 often parallel to one another, but the latter usually shortened by the length and obliquity of m.

Male hypopygium strongly compressed; tergite and sternite fused into a continuous ring; median region of tergite produced caudad into a simple or bifid depressed lobe, the apical margin of which is set with blackened spicules. Gonapophyses usually appearing as pale spatulate blades; a single or double tuft of yellow setæ jutting from notch of ninth sternite. Eighth sternite unarmed. Ovipositor with elongate, somewhat compressed cerci; hypovalvæ long, compressed.

Yamatotipula includes most members of the "Vittatæ," the so-called *lateralis* or *tricolor* groups of the genus. Some included species have the wings clear or nearly so, but most have the pattern distinctly striped longitudinally with brown and white (compare also some *Acutipula*). A few species have m-cu

slightly more distad in position. The subgenus is closest to the typical group *Tipula*.

Species of the subgenus Yamatotipula.

1. PALÆARCTIC EASTERN ASIA

aino Alexander.
fumida Alexander.
latemarginata Alexander.
morigera Alexander.
nova Walker (*fumifasciata* Brunetti, *nohirai* Matsumura).
parvincisa Alexander.
patagiata Alexander.
poliocephala Alexander.
protrusa Alexander.
stackelbergi Alexander.
subsulphurea Alexander.
trifida Alexander.
usuriensis Alexander.
yamamuriana Alexander.

2. PALÆARCTIC CENTRAL ASIA

mongolica Alexander.
nova Walker (see 1).
poliocephala Alexander (see 1).

9. Subgenus ACUTIPULA Alexander

Tipula (*Acutipula*) ALEXANDER, Arkiv för Zoologi 16 No. 18 (1924) 11–12.

Tipula (*Acutipula*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 79.

Type.—*Tipula gaboonensis* Alexander. (Ethiopian.)

Antennæ short in both sexes, the flagellum with very long verticils that exceed the segments in length. Frontal prolongation of head long, with elongate simple nasus.

A group of setæ on propleura. Anepisternum and sternopleurite glabrous. Tibial spur formula 1–2–2; claws (male) with basal tooth. Squama in most or all of the local species (and likewise in the subgenotype) with setæ, these usually few in number, often only three to five, but distinctly present; veins beyond cord unusually glabrous, with trichia lacking or very sparse on outer branches of M and Cu. Venation: R_{1+2} entire; in the subgenotype and most other known species in the Ethiopian fauna;[4] veins R_{1+2} and R_3 tend to lie far cephalad, greatly reducing cell R_2, which is strongly pointed at proximal end; Rs short to very short, subequal to m-cu or less; R_{4+5} ending at or beyond wing tip; medial cells full, the veins usually arcuate; m-cu at or before fork of M_{3+4}. Wings of local species usually with a darkened cloud at near midlength of cell Cu, lacking only in a few species (*alboplagiata*, *bipenicillata*, *biramosa*, *dicladura*, *munda*, *obtusiloba*, *oncerodes*, *platycantha*, *saitamæ*, and *tokionis*).

[4] Alexander, Arkiv för Zoologi 16 No. 18 (1924) 11–12.

Male hypopygium with tergite and sternite fused into a ring; basistyle complete or represented by the ventral suture only; ninth tergite conspicuously produced into a depressed or cylindrical lobe that is either bilobed or simple at apex, this set with microscopic spicules. Outer dististyle broadly flattened, of various shapes; discal setæ very sparse, marginal setæ more abundant, especially near base. Inner dististyle (in local species) with a very characteristic basic plan, but varying infinitely in the details in different species; it consists of a blackened beak on basal portion, with a second outer lobe (Plate 2, fig. 34; Plate 3, fig. 35) that is usually tipped or crowned with setæ; in some species (including *quadrinotata*, the commonest and most wide-spread form in eastern Asia) with an additional sclerotized rod between these two lobes. Caudal margin and surface of eighth sternite variously shaped, in cases with a median lobe, in others with a median crest of setæ back from margin, in still other species with lateral rows of setæ. Ovipositor with slender, straight cerci, the margins smooth; hypovalvæ subequal in length, compressed.

Species of the subgenus Acutipula.

1. PALÆARCTIC EASTERN ASIA

acanthophora Alexander.
alboplagiata Alexander.
bipenicillata Alexander.
bubo Alexander.
cockerelliana Alexander.
kuzuensis Alexander.
obtusiloba Alexander.
quadrinotata Brunetti (*fumicosta* Brunetti, *shirakii* Edwards, *pseudofulvipennis* de Meijere).
saitamæ Alexander.
tokionis Alexander.
turbida Alexander.
vana Alexander.

2. PALÆARCTIC CENTRAL ASIA

atuntzuensis Edwards.
biramosa Alexander.
bistyligera sp. nov.
brunnirostris Edwards.
captiosa Alexander.
cockerelliana Alexander (see 1).
desidiosa Alexander.
dicladura Alexander.
graphiptera Alexander.
incorrupta Alexander.
intacta Alexander.
interrupta Brunetti.
latifasciata Alexander.
megaleuca Alexander.
melampodia sp. nov.
munda Brunetti (*vicaria* Walker, preoccupied).
omeiensis Alexander.
oncerodes Alexander.
pertinax Alexander.
platycantha Alexander.
princeps Brunetti (*fuscinervis* Brunetti).
quadrinotata Brunetti (see 1).
robusta Brunetti (*fumifascipennis* Brunetti, *nigrotibialis* Brunetti).
subturbida Alexander.
yunnanica Edwards.

3. ORIENTAL EASTERN ASIA

de meijerei Edwards.
jacobsoni Edwards.
quadrinotata Brunetti (see 1).
umbrinoides Alexander.

TIPULA (ACUTIPULA) MELAMPODIA sp. nov. Plate 1, fig. 8; Plate 2, figs. 33, 34.

Allied to *graphiptera;* mesonotal præscutum dark gray, with four brown stripes, the anterior ends of the intermediate pair blending with the ground color; legs black, only the femoral bases narrowly yellow; pleura gray; wing pattern almost exactly as in *graphiptera;* basal abdominal segments obscure yellow, the outer segments black; male hypopygium with the median lobe of tergite simple but relatively broad; crest of subterminal lobe or beak high; eighth sternite with a median crest of yellow setæ.

Male.—Length, 16 to 17 millimeters; wing, 21 to 22; antenna, 5.5.

Frontal prolongation of head brownish black, the sides still darker; nasus elongate, black; palpi black. Antennæ with scape and pedicel brownish yellow; flagellum black, the base of the first segment narrowly pale. Head dark gray.

Mesonotal præscutum dark gray, with four brown stripes, the anterior ends of the intermediate pair blending with the ground color; posterior sclerites of mesonotum gray, the scutal lobes variegated by brown. Pleura chiefly light gray; dorsopleural membrane dusky. Halteres brownish black, the apices of knobs slightly paler. Legs with the coxæ gray; trochanters obscure yellow; femora black, only the extreme bases yellow, even narrower on the posterior legs; tibiæ and tarsi black. Wings (Plate 1, fig. 8) with pattern almost exactly as in *graphiptera;* brown, patterned with white, including a band across the bases of the outer medial cells, reaching the wing margin in outer half of cell R_5; white area in cell M not or scarcely confluent with the pale area before stigma, being more or less broadly interrupted near outer end of vein M.

Abdomen with basal tergite darkened; second, and parts of third and fourth segments, chiefly obscure yellow, the succeeding segments passing into black; extreme caudal borders of the segments pale. Male hypopygium with median lobe of tergite (Plate 2, fig. 33, 9*t*) simple but relatively broad at tip, the apex truncated or very indistinctly emarginate, set with black spicules. Outer dististyle and inner dististyle shaped as in figures (Plate 2, fig. 34, *od, id*); setæ at crown of outer lobe of inner style about thirty in number; subterminal lobe or beak with the crest

unusually high. Eighth sternite with the median region of caudal margin not produced but with rather abundant setæ, which tend to form a median crest back from the margin.

Habitat.—China (Szechwan).

Holotype, male, Beh-Luh-Din, 30 miles north of Chengtu, altitude 6,000 feet, July 27, 1933 (*Graham*). Paratypes, 1 male, 1 broken specimen, O–Er, 26 miles north of Li–Fan, altitude 10,800 feet, August 16, 1933 (*Graham*).

The general appearance of the present fly is very much like that of *Tipula* (*Acutipula*) *graphiptera* Alexander, likewise from western China, but differing very conspicuously in the uniformly black legs. The male sex of *graphiptera* has not been described and it cannot be stated which of the hypopygial characters are distinctive.

TIPULA (ACUTIPULA) BISTYLIGERA sp. nov. Plate 1, fig. 9; Plate 3, fig. 35.

Mesonotum gray, the præscutum with two intermediate brown stripes, the lateral stripes obsolete; pleura gray; antennæ black, the pedicel yellowish brown; legs black, the femoral bases very narrowly yellow; wings with a very strong yellowish brown tinge, sparsely variegated by cream-colored and whitish areas, the latter including a moderately wide obliterative area at cord; abdomen with basal tergites slightly variegated by yellow, trivittate with blackish, the outer segments more uniformly blackened; male hypopygium with median lobe of tergite moderately broad but entire; inner dististyle with outer lobe terminating in two long slender spines; eighth sternite without specially modified lobes or hair brushes.

Male.—Length, about 16 millimeters; wing, 17.6.

Frontal prolongation of head blackish, gray pruinose; nasus distinct; palpi black. Antennæ with scape black, sparsely pruinose; pedicel yellowish brown; flagellum black, the longest verticils a little exceeding the segments. Head gray.

Mesonotal præscutum gray, with two intermediate brown stripes that become obsolete on their anterior third, separated from one another by a relatively wide vitta of the ground; lateral stripes obsolete; scutum uniformly gray, the lobes not variegated by darker; scutellum and mediotergite gray. Pleura gray, the dorsopleural region more brownish. Halteres brown. Legs with the coxæ gray; trochanters brownish yellow; femora black, only the very narrow bases yellow, the amount subequal on all legs; tibiæ and tarsi black. Wings (Plate 1, fig. 9) with a

very strong yellowish brown tinge, sparsely variegated by whitish and cream-colored areas; the latter include spots near base of cell 1st A, before and beyond a somewhat darker brown cloud in cell Cu, and an additional spot just beyond this level in cell M; the white areas include a moderately wide obliterative area at the cord, extending into the bases of cells M_3 and M_4; base of cell M_1 whitened; slight pale streaks in cells 2d M_2 and R_5; veins dark brown, pale in the obliterative areas.

Abdomen with basal tergite light gray dorsally, broadly brownish black on sides; tergites two and three yellow sublaterally, darkened medially and on lateral portions; succeeding segments becoming more uniformly dark grayish black, margined sublaterally by velvet black, the lateral borders pale, sparsely pruinose; basal sternites yellow, beyond the second passing through dark brown to black. Male hypopygium with the median lobe of the ninth tergite (Plate 3, fig. 35, 9*t*) relatively broad but entire, truncate across apex. Outer dististyle of moderate size, the apex obtusely rounded. Inner dististyle (Plate 3, fig. 35, *id*) with the outer lobe extended into two long straight spines that are not decussate but lie more or less parallel, the outer spine a little shorter and stouter than the inner, the latter with about four long setæ on margin near base; beak of style unusually high. Eighth sternite with the caudal margin evenly convex, not produced medially, the apex with abundant setæ that continue cephalad as a median group but nowhere form tufts or rows.

Habitat.—China (Szechwan-Tibet border).

Holotype, male, Mupin, altitude about 13,400 feet, June, 1929 (*Graham*).

The type of male hypopygium of the present fly, more especially the inner dististyle, is approached only by *Tipula* (*Acutipula*) *captiosa* Alexander and *T.* (*A.*) *pertinax* Alexander, both of Kansu, western China, which are in all regards entirely different species.

10. Subgenus INDOTIPULA Edwards

Tipula (*Indotipula*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 81.

Tipula (*Indotipula*) ALEXANDER, Philip. Journ. Sci. 49 (1932) 231–232.

Type.—*Tipula walkeri* Brunetti. (Oriental.)

Antennæ 12-segmented, the terminal segment reduced to a mere button; flagellum moderately elongate, the longest verticils

subequal in length to or exceeding the segments; flagellar segments simple or more rarely binodose. Frontal prolongation of head short; nasus long and conspicuous. Vertical tubercle very low or lacking.

Mesopleura glabrous. Præscutum having interspaces with very sparse setæ or even quite glabrous. Tibial spur formula 0–0–2 or 0–1–2; spurs of posterior tibiæ unequal; claws (male) toothed. Squama naked; outer medial veins with trichia lacking or greatly reduced in number. Venation: R_{1+2} entire; Rs of moderate length, subequal to m-cu, in cases a little longer or shorter but not disproportionately so; cell M_1 petioled or sessile; m-cu before the level of r-m, at or close to fork of M_{3+4}, the position slightly variable even within the limits of a single species; cell 2d A narrow to very narrow.

Male hypopygium with the tergite separated from the sternite, at least in large part. Posterior margin of tergite produced into a usually bifid lobe that is set with blackened spicules. Basistyle separated from sternite by an incomplete ventral suture. Outer dististyle moderately compressed, with abundant setæ, longer on the margin. Inner dististyle variously modified, in normal forms relatively simple, the outer margin usually with a series of from six to twenty modified setæ that are flattened at their bases. Eighth sternite unarmed. Ovipositor with both cerci and hypovalvæ long and slender, smooth-margined.

Indotipula includes a monotonous aggregation of pale-colored species, with plain wings. It is the dominant group in parts of the Oriental Region and extends its range farther to the southeast than any other subgenus of the genus (*diclava* and *leptoneura* in northern Australia).

Species of the subgenus Indotipula.

1. PALÆARCTIC EASTERN ASIA

suensoni Alexander.
yamata Alexander.

2. PALÆARCTIC CENTRAL ASIA

cinctoterminalis Brunetti (somewhat doubtful, may be an *Acutipula*).
divisa Brunetti.
gracilis Brunetti.
simlensis Edwards.
subyamata Alexander.
tukvarensis Edwards.
walkeri Brunetti (*fulvipennis* Wlk. preoccupied; *tenuipes* Brunetti).

3. ORIENTAL EASTERN ASIA

acentrota Edwards.
angustilobata Alexander.
brevivittata Edwards.
demarcata Brunetti.
diclava Alexander.
elegantula Brunetti.
fuscoangustata Alexander.
gedehicola Alexander.
ifugao Alexander.
kinabaluensis Edwards.
korinchiensis Edwards.
latilobata Alexander.
leptoneura Alexander.
leucopyga van der Wulp (*sulaica* Walker, nondescript).
malaica Edwards.
manobo Alexander.
nudicaudata Edwards.
okinawensis Alexander.
palnica Edwards.
riverai Alexander.
sinabangensis de Meijere.
ubensis Alexander.
vilis Walker.

11. Subgenus PAPUATIPULA Alexander

Tipula (*Papuatipula*) ALEXANDER, Proc. Linn. Soc. New South Wales 59 (1934) in press.

Type.—*Tipula novæ-britannicæ* Alexander. (Australasian.)

Antennæ 13-segmented; flagellar segments with verticils that greatly exceed the segments in length. Frontal prolongation of head elongate, subequal to remainder of head; nasus distinct.

Tibial spur formula 1–2–2; spurs long and conspicuous. Squama naked; trichia of veins beyond cord unusually sparse and scattered there being a loose series on R_{4+5} and M_1. Venation: R_{1+2} entirely atrophied or represented only by a short basal spur; Rs unusually short but not transverse, approximately two-thirds m-cu; R_{2+3} very long and straight, exceeding twice m-cu; vein R_3 elongate, lying unusually close to costal border of wing, subequal in length to R_{2+3}; cell 1st M_2 elongate, its inner end strongly pointed; cell M_1 deep; m-cu uniting with M_{3+4} some distance before its fork, usually at near midlength.

Male hypopygium with the tergite separated from the sternite by a suture, fused only at extreme cephalic portion; basistyle fused with sternite. Tergite notched medially. Outer dististyle armed with a spinous point. Eighth sternite unarmed.

This subgenus has proved to be the most characteristic one in New Guinea and its satellite islands and will probably be found to be very rich in number of species when the region becomes better known. It is most nearly allied to *Acutipula* Alexander, *Tipulodina* Enderlein, and *Indotipula* Edwards, especially the first of these. It is distinguished by the venation, naked squama, and fundamentals of the male hypopygium, as the unfused tergite and sternite, notched tergite, and armed outer dististyle.

Species of the subgenus Papuatipula.

3. ORIENTAL EASTERN ASIA

divergens de Meijere.
leucosticta Alexander.
meijereana Alexander (*dentata* de Meijere, preoccupied).
novæ-britannicæ Alexander.
omissinervis (de Meijere).

12. Subgenus TIPULODINA Enderlein

Tipulodina ENDERLEIN, Zool. Jahrb., Syst. 32 (1912) 30–31.
Tipulodina BRUNETTI, Rec. Indian Mus. 15 (1918) 270–273.
Tipula (*Tipulodina*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 76.
Tipula (*Tipula*) ALEXANDER, Philip. Journ. Sci. 49 (1932) 232.

Type.—Tipulodina magnicornis Enderlein. (Oriental.)

Antennæ relatively short to long; flagellar segments not greatly incised; verticils long and conspicuous, exceeding the segments in length except in those species where the antennæ are very long. Frontal prolongation of head relatively short; nasus long and conspicuous. Usually with a small papillalike vertical tubercle.

Mesopleura glabrous; præscutal interspaces with very sparse setæ. Legs very long but not unusually slender; tibial spur formula 1–2–2; claws simple. Squama naked; outer medial veins with trichia quite lacking; outer radial veins often with a sparse series. Venation: R_{1+2} entire; Rs short to very short, less than m-cu, which is subequal to or longer than the distal section of Cu_1, cell M_4 thus being very short and broad; R_{4+5} long, decurved, ending beyond the wing tip; m-cu variable in position, from close to the fork of M_{3+4} to near midlength of this vein; cells M_1 and 1st M_2 full; cell 2d A narrow to very narrow.

Male hypopygium with the tergite separated from the sternite; basistyle fused with the sternite; ventrad of the dististyles, the basistyle is produced into a sclerotized rod or hook, joined at the base by a suture and not a direct prolongation of the basistyle. Outer dististyle small, broadly flattened. Ninth tergite with caudal margin more or less transverse, with a group of spinous setæ on either side of the median line. Eighth sternite often produced caudal into an acute median point. Ovipositor with cerci relatively stout, gently upcurved, the tips obtuse; hypovalvæ long, compressed.

The species of *Tipulodina* are all of large or medium size, with very long legs that are almost invariably ringed with snowy

white on the femora, tibiæ, or basitarsi. Such annuli are lacking or obscured in only a few species in the local fauna. The wings are usually crystal clear, iridescent, heavily patterned with dark or at least with the wing tip darkened; a few species have the wings beautifully tinted with amber yellow; still others have a darkened cloud at near midlength of cell M. The subgenus is eminently characteristic of the Oriental Region, with fewer species in the Ethiopian and others extending northward into Palæarctic Eastern Asia.

Species of the subgenus Tipulodina.

1. PALÆARCTIC EASTERN ASIA

joana Alexander.
nipponica Alexander.
taiwanica Alexander.

2. PALÆARCTIC CENTRAL ASIA

monozona Edwards.
patricia Brunetti.

3. ORIENTAL EASTERN ASIA

ætherea de Meijere.
albiprivata Edwards.
barraudi Edwards.
brunettiella Alexander.
cagayanensis Alexander.
ceylonica Edwards.
cinctipes de Meijere.
contigua Brunetti.
deprivata Alexander.
fumifinis Walker.
fuscitarsis Edwards.
gracillima Brunetti.
lumpurensis Edwards.
luzonica Alexander.
magnicornis Enderlein.
mckeani Cockerell.
micracantha Alexander.
pampangensis Alexander.
pedata Wiedemann.
sandersoni Edwards.
scimitar Alexander.
sidapurensis Edwards.
simillima Brunetti.
succinipennis Alexander.
tabuanensis Alexander.
tinctipes Edwards.
varitarsis Alexander.
venusta Walker.

13. Subgenus ARCTOTIPULA Alexander

Tipula (*Arctotipula*) ALEXANDER, Philip. Journ. Sci. 52 (1933) 410–411.

Type.—*Tipula besselsi* Osten Sacken. (Nearctic, Polar.)

Antennæ of moderate length, the flagellar segments feebly incised, with verticils that are shorter than the segments. Nasus in most cases relatively short, sometimes lacking.

Body conspicuously hairy, with setæ on all coxæ and usually on sternopleurite and meron but not on anepisternum. Tibial spur formula 1–2–2; claws simple. Squama naked; veins beyond cord without trichia or with these much reduced in size and

number, most persistent as a loose series on R_{4+5}; in some species, as *gavronskii*, the trichia are more abundant.

Abdomen often depressed. Male hypopygium of simple structure; tergite and sternite separate; eighth sternite unarmed. Terminal abdominal segments in female abruptly narrowed, the ovipositor very small; cerci moderately elongate and only weakly sclerotized, with smooth margins; hypovalvæ small and compressed.

The subgenus is distinguished from *Vestiplex* chiefly by the long, pale body vestiture, the unusually glabrous nature of the wing veins, and the structure of the ovipositor. *Tipula tundrensis* is aberrant in the subgenus and may possibly be better referred to *Vestiplex* despite the smooth-margined cerci. The species are chiefly far northern in their distribution.

Species of the subgenus Arctotipula.

1. PALÆARCTIC EASTERN ASIA

gavronskii Alexander.	*popoffi* Alexander.
hirtitergata Alexander.	*tundrensis* Alexander.

14. Subgenus VESTIPLEX Bezzi

Tipula (*Vestiplex*) BEZZI, Ann. Mus. Civ. Nat. Stor. Genova 51 (1924) 230–231.

Tipula (*Vestiplex*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 79–80.

Tipula (*Vestiplex*) ALEXANDER, Philip. Journ. Sci. 52 (1933) 396–398.

Type.—*Tipula cisalpina* Riedel. (Western Palæarctic.)

Antennæ short to elongate, in males of many species with flagellar segments very strongly incised; verticils of moderate length. Frontal prolongation of head elongate; nasus present or lacking.

Thoracic pleura usually glabrous, in cases (as *arctica*) with numerous setæ on sternopleurite. Tibial spur formula 1–2–2; claws (male) simple or with basal tooth (as *arctica*); legs usually stout, especially in females. Squama naked; branches of M with sparse to more abundant trichia. Venation: R_{1+2} entire; Rs long, fully one-half longer than m-cu or often considerably longer; m-cu at or close to fork of M_{3+4} and approximately opposite one-third to one-half the length of cell 1st M_2.

Male hypopygium in many species with the posterior half of tergite forming a shallow saucer, in some species heavily sclero-

tized and blackened, having the lateral angles produced caudad into acute spines. Still other species have the tergite completely divided longitudinally by pale membrane. The modifications of the hypopygium in this subgenus have been discussed in greater detail in another paper.[5] Ovipositor with the cerci strong and powerfully constructed, heavily sclerotized, horizontally placed and with the outer margin serrate; hypovalvæ very small or rudimentary, not or scarcely extending beyond the bases of the cerci. In several species the margins of the cerci have the teeth obtuse and evidently in process of being eliminated. Several species in the local fauna have been placed in *Vestiplex* with considerable question, many of these (all where the female sex is definitely known) have the cerci quite smooth and the hypovalvæ better developed. The following species, referred to *Vestiplex* in the past, are questionable and are better placed in *Oreomyza* until their characters are better known: *arisanensis, coxitalis, deserrata, foliacea, nestor, optanda, parvapiculata, quadrifulva, sternotuberculata,* and *terebrata*. The disposition of *tundrensis* in *Arctotipula* has been discussed under this generic name. Still further species belonging to the so-called *himalayensis* group, including *himalayensis* and *inæquidentata*, may likewise be found to fall in some other group but are retained herewith in *Vestiplex* until the female sex is better known.

Vestiplex includes a considerable part of the so-called "Marmoratæ," having marbled or marmorate wing patterns (compare also *Nippotipula, Sinotipula, Oreomyza,* and *Lunatipula*). The subgenus is widely distributed throughout the Holarctic region, more especially in the boreal portions and in the mountainous districts to the south.

Species of the subgenus Vestiplex.

1. PALÆARCTIC EASTERN ASIA

asio Alexander.
bicornuta Alexander.
biserra Edwards.
coquillettiana Alexander.
excisoides Alexander.
immunda Alexander.
jakut Alexander.
kamtchatkana Alexander.
kuwayamai Alexander.
nokonis Alexander.
pallitergata Alexander.
serricauda Alexander.
serridens Alexander.
subapterogyne Alexander.
subcentralis Alexander.
tchukchi Alexander.
teshionis Alexander.
transbaikalica Alexander.
verecunda Alexander.

[5] Alexander, Philip. Journ. Sci. 52 (1933) 396.

2. PALÆARCTIC CENTRAL ASIA

arctica Curtis (*aquilonia* Erichson).
avicularia Edwards.
bifida Alexander.
divisotergata Alexander.
edentata Alexander.
grahami Alexander.
hedini Alexander.
himalayensis Brunetti.
hummeli Alexander.
immota Alexander.
inæquidentata Alexander.
kwanhsienana Alexander.
leucoprocta Mik.
mediovittata Mik.
mitchelli Edwards.
nigroapicalis Brunetti.
pleuracantha Edwards.
quasimarmoratipennis Brunetti.
reposita Walker (*brevis* Brunetti).
scandens Edwards.
styligera Alexander.
subcarinata Alexander.
subscripta Edwards.
subtincta Brunetti.
tardigrada Edwards.
testata sp. nov.
tumulta Alexander.
virgatula Riedel.

3. ORIENTAL EASTERN ASIA

gedehana de Meijere.
papandajanica Edwards.

TIPULA (VESTIPLEX) TESTATA sp. nov. Plate 1, fig. 10; Plate 3, fig. 36.

Thorax yellow, the præscutum with three poorly indicated olive-brown stripes; antennæ (male) elongate, approximately one-half the length of body; flagellum black; legs black, the femoral bases narrowly yellow; wings tinged with brown, vaguely patterned with whitish areas, including an incomplete band beyond stigma; cell Sc uniformly black; R_{1+2} entire; basal abdominal tergites yellow, the outer segments black; male hypopygium with the basistyle terminating in an acute spine.

Male.—Length, 11 to 12 millimeters; wing, 12 to 13.5; antenna, 6.

Frontal prolongation of head orange-yellow, including the elongate nasus; palpi brown. Antennæ (male) elongate, if bent backward extending approximately to opposite the base of the fourth abdominal segment; scape and pedicel yellow, flagellum black, the base of the first flagellar segment paler; flagellar segments with verticils much shorter than the segments. Head brownish yellow.

Mesonotal præscutum golden yellow, with three olive-brown stripes that are poorly defined against the ground, the median one insensibly divided by paler color on posterior half; scutal lobes yellow, each with two olive-brown areas; scutellum brownish yellow; mediotergite more golden yellow, the two latter

sclerites with vague indications of a capillary dark vitta. Pleura uniformly yellow. Halteres with stem yellow, the knobs black. Legs with coxæ and trochanters yellow; remainder of legs black, the femoral bases rather narrowly yellow. Wings (Plate 1, fig. 10) with a weak brown tinge, very vaguely marked with more-whitish areas; prearcular field yellow; cell C brownish yellow, somewhat darker on outer end; cell Sc uniformly blackened throughout its length; stigma and a confluent cloud on anterior cord darker brown; a small dark cloud at origin of Rs; the whitish markings include an incomplete poststigmal fascia that passes through cell 1st M_2 into the base of cell M_3; extensive whitish areas before and beyond origin of Rs; bases of cells R, M, Cu, and the anals pale, cell Cu_1 restrictedly darkened, yellow at extreme base; veins dark brown. Venation: R_{1+2} with a series of trichia virtually to tip; petiole of cell M_1 a trifle longer than m.

Basal abdominal tergites yellow, beyond the second tergite more brownish yellow; fifth and succeeding segments, including the entire hypopygium, intense black; sternites colored like the tergites but lateral borders of outer blackened segments more conspicuously pale. Male hypopygium (Plate 3, fig. 36) with the sternite and tergite, *9t*, fused on cephalic half, separated by a suture on posterior half; basistyle, *b*, entirely cut off from the sternite, at apex produced into a gently curved black spine, the tip acute. Ninth tergite, *9t*, narrowly divided at midline by pale membrane; lateral lobes moderately elongate, black, with conspicuous black setæ; ventrad of lateral lobes with the usual glabrous blackened protuberances. Outer dististyle dusky, flattened, with abundant black setæ. Inner dististyle, *id*, with a blackened knob at base. Eighth sternite, *8s*, unarmed.

Habitat.—China (Szechwan).

Holotype, male, Beh-Luh-Din, 30 miles north of Chengtu, altitude 6,000 feet, August 8 to 10, 1933 (*Graham*). Paratopotypes, 3 males, August 12 to 17, 1933.

Tipula (*Vestiplex*) *testata* is readily told from all other small regional species of the subgenus that have the basistyle of the male hypopygium armed with a spine, by the yellow coloration of the thorax and very elongate antennæ of the male.

15. Subgenus OREOMYZA Pokorny

Oreomyza POKORNY, Wien. Ent. Zeit. 6 (1887) 50.

Tipula (*Oreomyza*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 75–76.

Type.—*Oreomyza glacialis* Pokorny. (Western Palæarctic.)

Antennæ short to moderately elongate, 13- to 15-segmented; flagellar segments weakly to strongly incised; verticils of moderate length. Frontal prolongation of head relatively elongate; nasus of moderate length or lacking (*carinifrons* group).

Mesopleura glabrous. Tibial spur formula normally 1–2–2; claws (male) simple, or more usually (as in *marmorata*, *trivittata*, and *unca* groups) with basal tooth. Squama naked; outer branches of M with trichia. Venation: R_{1+2} entire or, in numerous species (*mutila* group), entirely or partly atrophied; Rs of moderate length, exceeding m-cu, the latter some distance beyond fork of M, except in the *marmorata* and a few other groups.

Male hypopygium with tergite and sternite distinct; basistyle complete, at least in the majority of species; in certain forms, the basistyle produced caudad into an obtuse or acute lobe. Outer dististyle usually depressed, often dilated on outer portion into a more or less triangular head; in cases, dististyle small and nearly cylindrical. Eighth sternite simple or provided with hair brushes. Ovipositor with slender, smooth-margined, sclerotized cerci; hypovalvæ compressed, shorter than the cerci.

Oreomyza is very rich in species throughout the entire Holarctic region, being especially well developed in the local fauna. It includes the majority of the so-called "Marmoratæ," species with the wings variously clouded and spotted with brown, gray, and pale colors. Many forms in the local fauna have the wings unmarked or nearly so. The essential point of difference from *Lunatipula* lies in the glabrous squamæ, a character that in some groups, at least, may not prove to be of fundamental importance and which may tend to separate species that are in reality nearly allied. I am modifying the limits of the group to include species with simple and with toothed claws in the male sex.

As above constituted, *Oreomyza* includes several diverse elements, some of which later may be removed to other groups. The chief points of contact are with *Vestiplex* and *Lunatipula*, as discussed before. The host of species in our fauna are divisable into several natural groups, of which the following may be outlined provisionally at this time:

1. *arisanensis* group, including *arisanensis* and *foliacea*.
2. *coxitalis* group, including *coxitalis* and *sternotuberculata*.

3. *carinifrons* group, including *carinifrons, crawfordi, gynaptera,* and *malaisei.*
4. *flavolineata* group, including *curvicauda, dichroistigma, fortistyla, isshikii, nigrosignata,* and probably *westwoodiana.*
5. *juncea* group, including *longicauda* and *mystica.*
6. *marmorata* group, including *coreana, cupida, docilis, fidelis,* and *kiushiuensis.*
7. *mutila* group, including many species, possibly artificially distributed, as *edwardsella, flavocostalis, futilis, hibii, hylæa, latiflava, mutiloides, obnata, percara, quadrifasciata, striatipennis, subfutilis, submutila, sunda,* and others.
8. *seticellula* group, including *seticellula.*
9. *trivittata* group (claws of male toothed), as *apicispina* and many others.
10. *variipennis* group (claws of male simple), as *mesacantha* and many others.
11. *unca* or *borealis* group, including *amurensis.*

Species of the subgenus Oreomyza.

1. PALÆARCTIC EASTERN ASIA

amurensis Alexander.
apicispina Alexander.
arisanensis Edwards.
autumna Alexander.
chernavini Alexander.
coreana Alexander.
coxitalis Alexander.
crawfordi Alexander.
cupida Alexander.
curvicauda Alexander.
depressa Alexander.
derbecki Alexander.
dershavini Alexander.
dichroistigma Alexander.
docilis Alexander.
edwardsella Alexander (*flavicosta* Edwards, preoccupied).
famula sp. nov.
fidelis Alexander.
flavocostalis Alexander.
foliacea Alexander.
fortistyla Alexander.
futilis Alexander.
gynaptera Alexander.
hibii Alexander.
hylæa Alexander.
illegitima Alexander.
isshikii Alexander.
kiushiuensis Alexander.
lætibasis Alexander.
longicauda Matsumura.
lundströmiana Alexander.
machidai Alexander.
malaisei Alexander.
matsumuriana Alexander.
mendax Alexander.
mesacantha Alexander.
mitiphora Alexander.
mystica Alexander.
nestor Alexander.
nigrosignata Alexander.
nippoalpina Alexander.
obnata Alexander.
otiosa Alexander.
parvapiculata Alexander.
phæopasta Alexander.
pluriguttata Alexander.
politostriata Alexander.
pollex Alexander.
quadrifasciata Matsumura (*aluco* Alexander).
quadrifulva Edwards (probably here).
quadrispicata Alexander.
sachalinensis Alexander.
sempiterna Alexander.
seticellula Alexander.
s. longiligula Alexander.

Species of the subgenus Oreomyza—Continued.

1. PALÆARCTIC EASTERN ASIA—continued.

shomio Alexander.
sibiriensis Alexander.
sternotuberculata Alexander.
strix Alexander.
subfutilis Alexander.
subyusou Alexander.
superciliosa Alexander.
taikun Alexander.
tantula Alexander.
terebrata Edwards.
tetracantha Alexander.
tridentata Alexander.
trupheoneura Alexander.
uenoi Alexander.
westwoodiana Alexander.
yusou Alexander.
yusouoides Alexander.

2. PALÆARCTIC CENTRAL ASIA

amytis Alexander.
bipendula Alexander.
carinifrons Holmgren.
ciliata Lundström.
crassicornis Zetterstedt.
cruciata Edwards.
deserrata Alexander.
dolosa Alexander.
finitima Alexander
glaucocinerea Lundström.
haplorhabda sp. nov.
hirsutipes Lackschewitz.
jedoensis Alexander.
latiflava Alexander.
latistriga Edwards.
legalis Alexander.
leucosema Edwards.
leucosticta Edwards.
limbinervis Edwards.
lionota Holmgren.
macarta Alexander.
multistrigata Alexander.
mupinensis Alexander.
mutiloides Alexander.
optanda Alexander.
pedicellaris Alexander.
percara Alexander.
resupina Alexander.
rudis sp. nov.
stagnicola Holmgren.
striatipennis Brunetti.
submutila Alexander.
tetragramma Edwards.
tetramelania sp. nov.
tristriata Lundström.
vitiosa Alexander.
vivax Alexander.

3. ORIENTAL EASTERN ASIA

sunda Alexander.

TIPULA (OREOMYZA) FAMULA sp. nov. Plate 1, fig. 11; Plate 3, fig. 37.

General coloration gray, the præscutum with three brown stripes; setigerous punctures of interspaces sparse but conspicuous; a median dark vitta on posterior sclerites of mesonotum; antennæ (male) unusually long, exceeding one-half the length of body, the flagellar segments uniformly darkened, strongly nodulose; wings brown, sparsely variegated by dark brown and pale yellow areas, the latter including an incomplete fascia beyond cord; cell C infumed; R_{1-2} complete; basal abdominal segments reddish yellow, the outer segments black; male hypopygium with the caudal margin of tergite tridentate; eighth sternite with a fringe of long yellow setæ.

Male.—Length, about 12 millimeters; wing, 13; antenna, about 6.8.

Frontal prolongation of head dark gray; nasus distinct; palpi black. Antennæ (male) unusually long, exceeding one-half the length of body, if bent backward extending about to the base of the fourth abdominal tergite; scape and pedicel obscure yellow; succeeding segments almost uniformly dark brown; flagellar segments beyond the first strongly nodulose, much as in *serta* and allies; longest verticils subequal in length to the segments; terminal segment exceeding one-half the length of the penultimate. Head brownish gray; anterior vertex with an impressed median line back from the summit of the tubercle.

Mesonotal præscutum gray, with three brown stripes, the lateral pair entire, the median stripe with the central half entire, the lateral portions paler gray, this latter color continuing caudad almost to the posterior end of stripe as a delicate line just inside the dark lateral border of the stripe; setigerous punctures of the interspaces sparse, dark brown; scutum gray, each lobe with two dark brown areas; posterior sclerites of notum gray; a slightly interrupted brown median vitta extending from the suture to the abdomen. Pleura gray; dorsopleural membrane buffy yellow. Halteres obscure yellow, the bases of knobs dusky. Legs with the coxæ gray; trochanters yellow; femora obscure yellow, the tips rather broadly but weakly dark brown; tibiæ obscure yellow, the tips more extensively dark brown; tarsi black; claws (male) with a weak subbasal tooth. Wings (Plate 1, fig. 11) with a strong brown tinge, sparsely variegated by darker brown and cream-colored areas; prearcular field and cell Sc clear yellow; cell C infumed; stigma and a confluent area on anterior cord darker brown; wing apex almost uniformly darkened, a trifle paler in the outer medial field; an incomplete pale crossband beyond stigma, narrowly reaching the costa at vein R_{1+2}, behind extending into cell M_3; cells R and M darkened medially, variegated by pale at bases and in outer ends; a broad pale seam along outer third of vein 1st A; veins brown, brighter in the pale areas. Macrotrichia of veins relatively abundant; on more than basal half of R_{1+2}; a group of about seventeen trichia on posterior border of stigma. Venation: R_{1+2} entire but pale on distal third; cell 1st M_2 slightly elongate, the second section of M_{1+2} exceeding twice the basal section.

Abdomen with first segment brownish gray; succeeding three or four segments almost uniformly reddish yellow, the outer segments blackened. Male hypopygium (Plate 3, fig. 37) with the tergite, *9t*, entirely separated from the sternite, *9s*; basistyle entirely cut off from the sternite, its caudal margin not produced. Ninth tergite, *9t*, with the caudal margin tridentate, the lateral lobes obtuse, the median lobe acute and sending a median carina back onto the dorsal surface of the tergite; dorsal surface with abundant erect setæ. Outer dististyle broadly expanded on outer half. Inner dististyle, *id*, with a glabrous lobe on outer margin, directed outward; posterior basal angle of style produced caudad into a shorter, more obtuse lobe that is provided with scattered setæ. Eighth sternite, *8s*, on and near caudal margin with a dense median brush of long yellow setæ.

Habitat.—China (Chekiang).

Holotype, male, hills south of Ning-po, halfway to Nimrod Sound, May 1, 1925 (*E. Suenson*).

The present fly is very different from other regional species of *Oreomyza* in the elongate nodulose antennæ, which are very similar to the otherwise quite different *Tipula* (*Oreomyza*) *lundströmiana* Alexander and other members of the *serta* group. Aside from the antennæ, the present fly suggests species such as *T.* (*O.*) *futilis* Alexander and *T.* (*O.*) *legalis* Alexander, yet is very different.

TIPULA (OREOMYZA) TETRAMELANIA sp. nov. Plate 1, fig. 12; Plate 3, fig. 38.

Mesonotal præscutum gray, with four polished black stripes; antennal flagellum black; knobs of halteres blackened; legs yellow, the tips of the femora and tibiæ conspicuously blackened; wings brown, sparsely variegated by whitish and darker brown, including an incomplete pale fascia beyond the stigma; R_{1+2} entire; basal abdominal segments yellow, inconspicuously lined with darker; fifth and succeeding segments black; male hypopygium with the caudal margin of tergite trilobed; eighth sternite with a simple fringe of setæ on caudal border.

Male.—Length, 10 to 11 millimeters; wing, 10.5 to 12.

Female.—Length, 14 to 15 millimeters; wing, 13.5 to 14.

Frontal prolongation of head brown, narrowly blackened above; nasus elongate; palpi brown, the incisures paler, the outer segments brownish black. Antennæ moderately elongate, in male if bent backward extending nearly to root of halteres; scape and pedicel obscure yellow; flagellum black; verticils a

little longer than the segments. Head gray; anterior vertex relatively narrow.

Pronotum gray. Mesonotal præscutum gray with four conspicuous, polished black stripes, the intermediate pair separated by a diffuse line of the ground color; scutum gray, the lobes more blackened; scutellum polished black; mediotergite black, sparsely pruinose on sides. Pleura black, heavily pruinose, the ventral sternopleurites less heavily so, to appear somewhat polished. Halteres with the stem yellow, the knobs blackened. Legs with the coxæ dark brown, sparsely pruinose; femora and tibiæ obscure yellow, the tips conspicuously blackened; tarsi black, the proximal ends of basitarsi a little paler; claws (male) with basal spine. Wings (Plate 1, fig. 12) with the ground color brown, variegated by whitish and sparse darker brown areas; prearcular region and cell Sc yellow, cell C more brownish yellow; stigma and a confluent cloud on anterior cord darker brown; a narrow and incomplete pale crossband beyond cord, including bases of cells R_2, R_3, and R_5; in cases, the outer medial field pale, in still other specimens being of the ground color; a dark cloud in prearcular field, following the radial vein; an entire dark band extending from vein R to the posterior margin at near midlength of the basal cells of wing; veins brownish black, more yellowish in the flavous portions. Trichia of veins relatively short, virtually lacking on 1st A. Venation: R_{1+2} entire, with trichia except on the pale outer third; cell 1st M_2 relatively small.

Abdomen (male) with the basal four segments chiefly light yellow, the tergites usually very vaguely and indistinctly darkened medially and on the sides, the latter more evident, in cases the markings more distinct; sternites similarly light yellow, unmarked; outer abdominal segments, including hypopygium, black. In female, the basal abdominal tergites are more distinctly trivittate with black; genital shield obscure yellow. Male hypopygium (Plate 3, fig. 38) with the basistyle relatively small, entirely cut off from sternite by sutures. Ninth tergite, *9t*, a simple transverse plate, without blackened lobes or other modifications; caudal portion narrowed, the margin with three lobes, the lateral lobes broader and more obtuse than the slender median lobes. Outer dististyle, *od*, a little flattened, sinuous, with unusually long setæ. Inner dististyle, *id*, with the caudal or posterior margin notched, with a small, pale, conical point near

base. Eighth sternite, 8s, with posterior margin provided with a simple fringe of long yellow setæ, smaller and restricted in number near the midline. Ædeagus very stout. Ovipositor with the cerci long and slender, straight.

Habitat.—China (Szechwan).

Holotype, male, Beh-Luh-Din, 30 miles north of Chengtu, altitude 6,000 feet, August 18, 1933 (*Graham*). Allotopotype, female, August 2, 1933. Paratopotypes, 7 males and females, August 16 to 27, 1933. Paratype, 1 male, Mu-Sang-Tsai, 10 miles northwest of Wei-Chow, altitude 8,000 to 10,000 feet, July 2 to 6, 1933 (*Graham*).

Despite marked differences in coloration of body and wings, I believe the present fly to be related to *Tipula* (*Oreomyza*) *cruciata* Edwards and allies. It is amply distinct in the pattern of the thorax and abdomen, and in the details of structure of the male hypopygium, especially of the tergite.

TIPULA (OREOMYZA) RUDIS sp. nov. Plate 1, fig. 13; Plate 3, figs. 39 and 40.

Most nearly allied to *finitima*; mesonotal præscutum brownish gray, with four slightly darker brown stripes; scutellum uniformly darkened; wings strongly suffused with brownish yellow, the stigma darker; obliterative areas much restricted; basal abdominal segments yellowish, the outer segments darkened; male hypopygium with the basistyle large, entire, its caudal end produced into a broad, truncated, blackened lobe; eighth sternite with a fringe of setæ.

Male.—Length, about 15 millimeters; wing, 16; antenna, about 5.

Frontal prolongation of head brownish gray; nasus distinct; palpi brownish black. Antennæ (male) moderately elongate, as shown by the measurements; scape brownish yellow; pedicel yellow; flagellar segments weakly bicolorous, the basal enlargements of the segments dark brown, the remainder somewhat paler brown; longest verticils subequal in length to the segments. Head dark gray, the anterior vertex badly damaged in the unique type.

Mesonotal præscutum brownish gray, with indications of four slightly darker, more brownish stripes; scutum with lobes uniformly dark gray; posterior sclerites of notum dark gray. Pleura uniformly dark gray; dorsopleural membrane buffy yellow. Halteres with stem brownish yellow, the knobs darkened. Legs with the coxæ gray; trochanters brownish yellow; re-

mainder of legs broken. Wings (Plate 1, fig. 13) with a brownish yellow tinge, cells C, Sc, and Cu more saturated; stigma slightly darker brown; obliterative areas before and beyond stigma and across cord greatly reduced, very inconspicuous, especially the latter; veins brown. Venation: R_{1+2} entire; Rs somewhat longer than m-cu.

Abdomen with basal segments yellow, the tergites scarcely darkened medially; on third and succeeding tergites a narrow dark sublateral stripe begins, broadening behind; outer abdominal segments darkened. Male hypopygium (Plate 3, fig. 39) with the basistyle, *b*, very large, entirely cut off from the sternite, its caudal end broadly produced into a short, obtusely truncated, blackened lobe. Ninth tergite (Plate 3, fig. 40, 9*t*) long, narrowed on posterior third, with heavily blackened lateral lobe on either side and a low, paler, median lobe; dorsomedian portion of tergite narrowly but distinctly divided by pale membrane. Outer dististyle small, weakly clavate, with long setæ. Inner dististyle, *id*, with a setiferous lobe at base of posterior portion, connected with the head portion by extensive, almost clear membrane. Ninth sternite profoundly incised; on its margin, ventrad and cephalad of the basistyle, a tumid blackened lobe whose posterior portion bears abundant setæ. Eighth sternite, 8*s*, with median region of caudal margin very gently concave and provided with a fringe of long setæ.

Habitat.—China (Szechwan).

Holotype, male, O-Er, 26 miles north of Li-Fan, altitude 9,000 feet, August 6 to 16, 1933 (*Graham*).

The nearest described ally is the very similar *Tipula* (*Oreomyza*) *finitima* Alexander (Kansu), which differs especially in the structure of the male hypopygium, notably the basistyle and inner dististyle.

TIPULA (OREOMYZA) HAPLORHABDA sp. nov. Plate 1, fig. 14.

General coloration of thorax brownish gray, the præscutum with four dark brown stripes; femora black, with a broad yellow subterminal ring on all legs; wings whitish, variegated by grayish brown and darker brown areas, the pattern not so definitely quadrifasciate as in most members of the subgroup; white crossband beyond cord unusually broad; cell 2d A almost undarkened; vein R_{1+2} represented by a spur that includes about one-half the normal length of the vein.

Female.—Length, about 22 millimeters; wing, 18.5.

Frontal prolongation of head black, sparsely pruinose; nasus unusually elongate; palpi black. Antennæ black, the pedicel and apex of scape restrictedly brightened; scape elongate, exceeding in length the combined first and second flagellar segments; verticils subequal to the segments. Head gray.

Pronotum gray, with a median dark brown vitta. Mesonotal præscutum dark brownish gray, with four dark brown stripes, the intermediate pair separated throughout their length by a capillary line of the ground color; posterior sclerites of notum pruinose, the mediotergite clearer gray, with a capillary brown line. Pleura uniformly gray; dorsopleural region yellow. Halteres yellow, the knobs dark brown. Legs with the coxæ gray; trochanters brownish yellow; femora black, the extreme bases obscure yellow; a broad yellow subterminal ring on all femora, this subequal in width to the dark apex (forelegs) or much broader, about one-half wider than apex (hind legs); tibiæ brown to brownish black, paler at base, darker at tip; tarsi brownish black. Wings (Plate 1, fig. 14) whitish, variegated by grayish brown and dark brown areas; prearcular region and cells C and Sc uniformly pale; darker brown areas include the stigma and a major confluent area on anterior cord and on distal third of Rs; origin of Rs; bases of cells R and M; conspicuous seams along m-cu and distal section of Cu_1; darkened wing tip relatively narrow, including less than the distal half of cells R_2, R_3, or R_5; inner end of darkened apex about on a level with the fork of M_{1+2}; paler clouds in cells M, Cu, and 1st A; veins M_3 and 2d A narrowly seamed with dark brown; cell 2d A almost clear, its apical border narrowly darkened; veins brownish yellow, darker in the clouded areas. Venation: R_{1+2} preserved on about its basal half; Rs elongate, exceeding vein R_3.

Abdomen black, sparsely pruinose, the lateral borders somewhat broadly pruinose. Ovipositor with the genital shield polished black; cerci long and slender, brownish black.

Habitat.—China (Szechwan).

Holotype, female, O-Er, 26 miles north of Li-Fan, altitude 10,800 feet, August 16, 1933 (*Graham*).

The yellow subterminal rings on the femora remind one strongly of the condition found in *Tipula* (*Oreomyza*) *latiflava* Alexander (Szechwan), but the wing pattern is quite distinct, notably the clear cells C and Sc and the relatively narrow dark-

ened wing tip. The long basal spur of vein R_{1+2} is different from that found in any of the members of the *mutila* group. The fly is even closer to two Burmese species, *T.* (*O.*) *latistriga* Edwards and *T.* (*O.*) *leucosticta* Edwards, but differs in the thoracic pattern and the wing coloration, notably the unusually wide white band beyond the cord and the virtually immaculate cell 2d A.

16. Subgenus LUNATIPULA Edwards

Tipula (*Lunatipula*) EDWARDS, Ann. & Mag. Nat. Hist. X 8 (1931) 81–82.

Type.—Tipula lunata Linnæus. (Western Palæarctic.)

Antennæ usually short, the verticils exceeding the segments in length. Frontal prolongation of head relatively long, with short to long nasus.

Mesopleura usually glabrous, in cases (including the subgenotype) with a few setæ on sternopleurite and meron. Tibial spur formula 1–2–2; claws (male) with basal tooth. Squama with a group of setæ, these usually abundant; veins beyond cord with trichia. Venation: R_{1+2} usually entire, in some species (as *manca*) more or less atrophied; Rs variable in length, ranging from subequal to m-cu to more than twice this length; vein R_3 straight or nearly so; R_{4+5} ending before wing tip.

Male hypopygium with tergite and sternite distinct. Tergite almost invariably with a median notch. Outer dististyle small to merely depressed-clavate. Eighth sternite usually provided with hair brushes, pencils, or fleshy lobes. Ovipositor with cerci long and slender, smooth-margined; more rarely (*fascipennis* and *marmoratipennis* groups) with cerci and hypovalvæ short and fleshy.

Lunatipula includes a certain proportion of the so-called "Subunicolores," species with the wings unmarked or virtually so and with the obliterative area at the cord forming a conspicuous pale lunule against the ground color. Some of the groups include species with heavily patterned wings.

As here classified, the subgenus divides into more or less natural groups, of which the following may be indicated:

1. *lunata* group, including *polypogon* and several others.
2. *fascipennis* or *bicornis* group, including *annulicornuta*, *pseudogyne*, *tateyamæ*, *turanensis*, and *validicornis*.
3. *marmoratipennis* group, including *holoteles*, *marmoratipennis*, *multibarbata*, *multisetosa*, *naviculifer*, and *shogun*.

4. *macrolabis* group, including *macrolabis*.
5. *oreada* group, including *oreada*.

Species of the subgenus Lunatipula.

1. PALÆARCTIC EASTERN ASIA

ampliata Alexander.
annulicornuta Alexander.
flaccida Alexander (probably).
gondattii Alexander.
holoteles Alexander.
lamentaria Alexander.
macrolabis Loew.
manca Alexander.
multibarbata Alexander.
naviculifer Alexander.
pendula Alexander.
plagiotoma Alexander.
polypogon Alexander.
pseudogyne Alexander.
shogun Alexander.
sublimitata Alexander.
tateyamæ Alexander.
terebrina Alexander.
turanensis Alexander.
validicornis Alexander.

2. PALÆARCTIC CENTRAL ASIA

absconsa Alexander.
marmoratipennis Brunetti.
minensis Alexander.
multisetosa Alexander.
nigrobasalis Alexander.
oreada Alexander.
subvernalis Alexander (*fasciculata* Brunetti, preoccupied) (probably occurs in 2).
transfixa Alexander.
trialbosignata Alexander.
variipetiolaris Alexander.

Genus PRIONOCERA Loew

Prionocera LOEW, Stettin. Ent. Zeitg. 5 (1844) 170.
Stygeropis LOEW, Berlin. Ent. Zeitschr. 7 (1863) 298.

PRIONOCERA LÆTIPENNIS sp. nov. Plate 1, fig. 15; Plate 3, fig. 42.

General coloration brownish gray, the præscutum with four slightly darker stripes; antennæ with flagellar segments strongly nodulose, with short apical pedicels, the basal segments yellow; wings strongly suffused with yellow, the costal portions more saturated; abdomen yellow, with a continuous black median stripe on the tergites.

Male.—Length, about 12 to 13 millimeters; wing, 12.5 to 13.5.

Female.—Length, 15 to 16 millimeters; wing, 16 to 16.5.

Frontal prolongation of head of moderate length, obscure yellow, darker beneath; nasus long and slender; basal segments of palpi dark brown, the outer two-thirds of terminal segment paling to yellow. Antennæ with basal three segments yellow, the succeeding segment dark in middle, pale at both ends; third flagellar segment dark basally, the apex a little brightened; remainder of flagellum black; first flagellar segment long and

slender, exceeding the scape and about equal in length to the next two flagellar segments taken together (Plate 3, fig. 41); flagellar segments short and crowded, the basal enlargement strongly produced beneath; subterminal segment with a more slender apical neck that is subequal in length to the enlarged basal portion; terminal segment slender, subequal in length and only a little thicker than the pedicel of the penultimate segment; flagellar segments clothed with short abundant erect setæ and with two apical verticils at extreme apex of outer case. Head chiefly dark brown, deepest just behind the antennal fossæ; posterior orbits a little brighter; a capillary dark brown median vitta.

Mesonotal præscutum brown with four scarcely darker brown stripes, the intermediate pair separated by a capillary dark brown vitta; scutal lobes brownish gray; posterior sclerites of notum brownish yellow, sparsely pruinose. Pleura almost uniformly grayish white pruinose, the sternopleurite and ventral meron darker gray, the pteropleurite and pleurotergite clearer yellow. Halteres brownish yellow, the knobs darkened. Legs with the coxæ grayish white; trochanters yellow; femora yellow, the tips narrowly blackened; tibiæ brownish yellow, the tips narrowly darkened; tarsi yellowish brown, passing into black. Wings (Plate 1, fig. 15) strongly suffused with yellow; cell Sc clearer yellow, cell C a trifle more brownish yellow; stigma darker brown; cephalic portion of cells R and R_1 more suffused with pale brown; vague pale central streaks in cells M and 1st A; veins yellow to brownish yellow. Veins with sparse trichia, including a series on basal half of R_3 and a sparse scattered series on outer two-thirds of R_{4+5}; M, Cu, and anal veins glabrous. Venation: Rs subequal to R_3.

Abdominal tergites yellow, with a very conspicuous, continuous, black, median stripe that is narrow on the basal tergite, widening slightly behind, at widest point about equal to the pale lateral margins; sternites reddish yellow, the seventh to ninth segments more darkened. Male hypopygium with the tergite (Plate 3, fig. 42, 9*t*) transverse, the posterior border blackened, each outer lateral angle terminating in a small black tooth. Outer dististyle, *od*, flattened, on inner margin before apex with a tumid, setiferous lobe. Inner style, *id*, with apical beak elongate. Ovipositor with cerci relatively short, the tips obtuse, the basal portions relatively wide; surface fleshy, with microscopic yellow setulæ.

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet, June, 1929 (*Graham*). Allotopotype, female. Paratopotypes, 3 males and females. Paratypes, 1 male, Kwanhsien, May 28, 1930 (*Graham*); 1 female, Chengtu, altitude 1,700 feet, July 13 to 15, 1933 (*Graham*).

Prionocera lætipennis is readily told from *P. indica* Edwards (India, Assam, and French Indo-China) and *P. altivolans* sp. nov. (China-Tibet border) by the conspicuously brightened wings, which are strongly suffused with yellow, instead of the usual grayish tinge. The genus has not been recorded from China.

PRIONOCERA ALTIVOLANS sp. nov. Plate 1, fig. 16.

Female.—Length, about 14 to 15 millimeters; wing, 14 to 15.

Allied to *lætipennis* sp. nov., yet obviously distinct. The chief differences are as follows: Entire head, including the frontal prolongation, dark brown, the latter a trifle paler on sides. Antennæ brownish black throughout, including both scape and pedicel. Posterior parts of head variegated with silvery gray on orbits. Mesonotal præscutum with the dorsum almost uniformly dark brown, the stripes a little darker than the interspaces; capillary dark median vitta well indicated on cephalic half of sclerite; a dusky spot in humeral region, cephalad of the lateral stripes; posterior sclerites of notum much darker than in *lætipennis;* mediotergite clear gray. Legs with the femoral tips more broadly blackened. Wings (Plate 1, fig. 16) with the prearcular and subcostal fields, together with the narrow cell Cu_1, clear yellow, the remainder of wing more gray. Trichia on veins R_3 and R_{4+5} very sparse, especially reduced on the latter vein. Venation: Rs somewhat shorter and more arcuated. Abdomen with tergites chiefly dark brown, the lateral borders narrowly more yellowish; sternites dark. Ovipositor with cerci narrower on basal portion.

Habitat.—China (Szechwan-Tibet border).

Holotype, female, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*). Paratopotype, female.

Genus NEPHROTOMA Meigen

Nephrotoma MEIGEN, Illiger's Mag. **2** (1803) 262.
Pachyrrhina MACQUART, Suit. a Buffon **1** (1834) 88.

NEPHROTOMA RETENTA sp. nov. Plate 1, fig. 17; Plate 4, fig. 43.

Antennal flagellum black; occipital band black, its anterior end obtuse; margins of pronotal scutellum blackened; præscutal

stripes polished black, very narrowly margined with velvety black; scutellum brownish yellow; mediotergite yellow, with two more reddish yellow areas at posterior border; pleura yellow, variegated with reddish; fore femora extensively blackened; wings almost uniformly suffused with pale brownish yellow, the stigma scarcely darker; Sc_2 extending distinctly beyond origin of Rs, Sc_1 preserved; Rs long; abdominal tergites trivittate with black.

Male.—Length, about 11 millimeters; wing, 12.

Female.—Length, about 14 millimeters; wing, 13.

Frontal prolongation of head light yellow, narrowly blackened dorsally; nasus long and conspicuous, black; palpi black throughout. Antennæ with scape yellow; pedicel brownish yellow; base of first flagellar segment obscure yellow, the color continued up the lower face; remainder of flagellum black; flagellar segments relatively long and slender, slightly exceeding the longest verticils, only moderately incised; terminal segment small, subequal in length to the basal enlargement of the penultimate segment. Head orange, the summit of the vertical tubercle more yellowish; occipital brand black, conspicuous, subtriangular, its anterior end broadly obtuse, not surpassing the posterior vertex.

Pronotum yellow, the margins of the scutellum and propleura narrowly lined with black. Mesonotal præscutum yellow, with three shiny black stripes that are very narrowly bordered by velvety black; lateral stripes straight, but with a weak, somewhat paler area at their anterior ends giving the appearance of being outcurved; scutum light yellow, the lobes variegated with two confluent black areas; outer end of suture, laterad of the outer dark markings, narrowly bordered by black, in the female more extensively darkened; scutellum brownish yellow; mediotergite pale yellow, the posterior border with two more reddish yellow areas. Pleura yellow, more reddish on anepisternum, ventral sternopleurite, and ventral meron; posterior border of ventral pleurotergite narrowly darkened. Halteres pale brown, the knobs weakly darkened. Legs with the coxæ orange-yellow; trochanters obscure yellow; femora yellow, the tips blackened, more extensively so on the fore pair where about the distal half is darkened, much narrower on the posterior legs; tibiæ yellowish brown, the tips broadly blackened; tarsi black. Wings (Plate 1, fig. 17) almost uniformly suffused with pale brownish yellow, the prearcular region and cells C and Sc a trifle clearer

yellow; stigma very pale, scarcely darker than the ground; veins dark brown. Venation: Sc_2 extending distinctly beyond origin of Rs, Sc_1 preserved; Rs unusually long, subequal to R_{2+3}; cell M_1 rather broadly sessile; m-cu just before fork of vein M_4.

Abdomen yellow, the tergites trivittate with black, the median stripe in female unusually broad; sternites yellow, weakly darkened medially. Male hypopygium with the tergite (Plate 4, fig. 43, 9*t*) produced into acute spinous points on either side beneath the dorsal surface. Outer dististyle, *od*, long-attenuate. Inner dististyle, *id*, simple. Eighth sternite deeply emarginate, without lobes of any kind, the setal fringe moderately long and dense.

Habitat.—China (Szechwan-Tibet border).

Holotype, male, near Yien-Long-Shien, altitude 13,000 to 15,000 feet, August 3 to 6, 1930 (*Graham*). Allotype, female, Yin-Kuan-Tsai, altitude from 13,000 to 15,000 feet, July 25, 1930 (*Graham*).

The present fly is quite distinct from other previously described regional species in the diagnostic features listed, notably the immaculate wings with somewhat peculiar venation. It is more nearly allied to other species described at this time.

NEPHROTOMA ATTENUATA sp. nov. Plate 1, fig. 18; Plate 4, fig. 44.

Antennæ black, only the scape brightened above in certain cases; occipital brand black, sending an anterior prolongation almost to summit of vertical tubercle; præscutal stripes three, black, narrowly bordered by opaque velvety black; scutellum darkened; mediotergite yellow, with a pale brown median vitta; wings almost uniformly brownish yellow, the stigma a trifle darker; Sc_2 ending opposite origin of Rs; cell M_1 sessile; abdominal tergites trivittate with brownish black; male hypopygium with outer dististyle greatly attenuated.

Male.—Length, about 10 millimeters; wing, 11 to 11.5.

Frontal prolongation of head yellow, broadly dark brown above; palpi black throughout. Antennæ of moderate length, in male, if bent backward, extending to some distance beyond base of abdomen; in type specimen, black throughout; in paratypes, with the scape restrictedly yellow on upper face; flagellar segments very weakly incised. Head orange-yellow, the front light sulphur yellow; occipital brand very conspicuous, black, sending an anterior prolongation almost to summit of vertical

tubercle; a small black spot adjoining eyes behind each antennal fossa.

Pronotum light yellow, the scutellum very restrictedly darkened medially, more extensively so on sides. Mesonotal præscutum with three subnitidous black stripes that are narrowly bordered by opaque velvety black, the lateral stripes straight or with only a slight extension laterad of the velvety-black anterior ends; median stripe reaching the suture behind; scutum yellow, each lobe with two confluent subnitidous areas that are narrowly bordered by velvety black; scutellum weakly to strongly darkened, the parascutella darkened; mediotergite yellow, with a median pale brown line, the posterior border slightly more reddish. Pleura yellow, the anepisternum and ventral sternopleurite and meron more reddish; linear black dashes on posterior border of sternopleurite and anepisternum, ventral edge of pleurotergite, and posterior portion of lateral pretergites. Halteres dusky, the knobs more or less brightened. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips passing into black, broadest on the forelegs; tibiæ brown basally, passing into black; tarsi black. Wings (Plate 1, fig. 18) with a strong brownish yellow tinge, the stigma a trifle darker brown; veins dark brown to brownish black. Venation: Sc_2 ending opposite origin of the short Rs, Sc_1 lacking or preserved only as a basal spur; cell M_1 sessile; m-cu just before fork of M_4.

Abdominal tergites orange-yellow, narrowly trivittate with brownish black, the areas narrowly interrupted at the incisures; sternites yellow, unmarked. Male hypopygium with the outer dististyle (Plate 4, fig. 44, *od*) exceedingly produced and attenuated. Inner dististyle, *id*, with the beak slender, the outer portion elevated into a pale membranous crest that is produced caudad into a long tail-like portion. Ninth sternite just before the caudal margin of the eighth sternite with a small, pale, fingerlike lobe, directed ventrad and slightly cephalad. Eighth sternite with the caudal margin nearly transverse, not emarginate, but with the whole posterior third of the sclerite pale, with white membrane, on either side of which the setæ are longer and more aggregated.

Habitat.—China (Szechwan-Tibet border).

Holotype, male, near Yien-Long-Shien, altitude 13,000 to 15,000 feet, August 3 to 6, 1930 (*Graham*). Paratopotypes, 2 males.

The present fly is most generally similar to *Nephrotoma retenta* sp. nov., agreeing in the general coloration of the body and wings. It is very different in the details of coloration and venation, and especially in the structure of the male hypopygium.

NEPHROTOMA IMPIGRA sp. nov. Plate 1, fig. 19; Plate 4, fig. 45.

General coloration yellow; præscutum with three polished black stripes; scutellum brownish black or black; mediotergite darkened in central portion; antennæ (male) relatively long, if bent backward extending about to the base of abdomen; flagellum black; wings whitish subhyaline, cell Sc uniformly darkened; M_4 and m-cu both at or close to proximal end of cell 1st M_2; abdominal tergites yellow, with a median, brownish black stripe, narrowly interrupted at posterior borders of segments, the lateral stripes lacking; male hypopygium with lateral portions of tergite produced caudad into slender, straight, spikelike horns.

Male.—Length, 8.5 to 9 millimeters; wing, 9.5 to 10.

Female.—Length, 11 to 12 millimeters; wing, 11 to 11.5.

Frontal prolongation of head yellow, darker above, including the nasus; palpi brownish black, the outer segment somewhat paler. Antennæ in male relatively long, if bent backward extending about to base of abdomen; scape light yellow; pedicel obscure yellow; flagellum black; flagellar segments moderately incised, the verticils much shorter than the segments. Head orange-yellow; occipital brand brown, conspicuous, sending a median spurlike point to the base of vertical tubercle; orbital darkening barely indicated.

Pronotum broadly yellow medially, dark brown on sides. Mesonotal præscutum yellow, with three polished black stripes, the lateral pair usually with a faint brownish cloud opposite their outer cephalic end; scutum yellow, the lobes chiefly covered by polished black areas; scutellum brownish black to black, the parascutella yellow; mediotergite yellow, narrowly dark brown medially, the posterior border with two contiguous circular black areas. Pleura yellow, with reddish areas on anepisternum, ventral sternopleurite, ventral meron and on pleurotergite, the latter area encircling the ventral pleurotergal area. Halteres with stem brownish yellow, the base of knob darkened, the apex again brightened. Legs with the coxæ and trochanters yellow; femora chiefly dark brown, the bases restrictedly yellow; tibiæ brown, the tips passing into dark brown; tarsi brownish black. Wings

(Plate 1, fig. 19) whitish subhyaline; cell Sc uniformly darkened; stigma brown, moderately conspicuous; veins brownish black. Venation: Sc_1 present as a spur; Rs pale, subequal to basal section of R_{4+5}; cell M_1 petiolate; M_4 departing at fork of M, with m-cu at this same point, and so close to base of cell 1st M_2, in cases a little beyond the base, as in *distans*.

Abdominal tergites yellow, with a median brownish black stripe, narrowly interrupted at the posterior borders of the segments; lateral stripes quite lacking; on sixth and seventh segments the black color more extensive; sternites uniformly pale, the seventh and eighth more or less blackened; hypopygium pale. Male hypopygium with the ninth tergite (Plate 4, fig. 45, 9*t*) on either side projected into slender, straight, spikelike horns, each with a series of six or seven blackened points along their mesal edge; more mesally, the caudal margin of tergite is densely set with blackened points that are directed away from the median line. Dististyles, *od, id,* as figured. Eighth sternite with caudal border transverse, unarmed, the median region at and back from the margin with long abundant yellow setæ.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, August 10, 1929 (*Franck*). Allotopotype, female, pinned with type. Paratopotypes, 8 males and females, August 10 to 15, 1929 (*Franck*). Paratype, 1 male, Beh-Luh-Din, altitude 6,000 feet, August 23 to 24, 1933 (*Graham*).

The nearest ally is the species next described as *Nepthrotoma pilata* sp. nov., which differs especially in the details of coloration and structure of the male hypopygium.

NEPHROTOMA PILATA sp. nov. Plate 1, fig. 20; Plate 4, fig. 46.

Male.—Length, about 10 millimeters; wing, 10.5.

Generally similar and closely allied to *N. impigra* sp. nov., differing as follows:

Frontal prolongation of head entirely pale yellow, including the nasus, the vestiture light golden yellow. Occipital brand greatly reduced and poorly delimited, appearing only as an irregular brown suffusion; orbital darkenings small but evident. Præscutal stripes highly polished, very narrowly margined by velvety black; lateral stripes straight; central darkening of mediotergite extensive. Wings (Plate 1, fig. 20) a trifle more suffused with dusky. Venation: Cell M_1 very short-petiolate to nearly sessile. Darkenings on abdominal tergites more exten-

sive. Male hypopygium with the lateral spines of the tergite (Plate 4, fig. 46, 9*t*) broad-based, the tips obliquely truncated; groups of spines on caudal border of tergite more compact, subglobular in outline. Dististyles, *od, id,* as shown; inner style very deep. Eighth sternite nearly transverse across caudal margin, at midline of posterior edge with a small compressed lobe, directed ventrad, truncated at apex; surface of sternite behind this lobe with long, conspicuous, yellow setæ.

Habitat.—China (Szechwan).

Holotype, male, Chengtu, altitude 1,700 feet, April 11 to 14, 1933 (*Graham*).

NEPHROTOMA IMMEMORATA sp. nov. Plate 1, fig. 21; Plate 4, fig. 47.

General coloration yellow, the præscutum with three polished black stripes, the lateral pair outcurved; occipital brand scarcely evident; prothorax entirely pale yellow; mediotergite yellow, darkened only on posterior border; knobs of halteres pale yellow; wings with a very faint brown tinge, the cord and extreme wing tip darkened; cell M_1 short-petiolate; abdomen yellow, the tergites with an interrupted series of median spots; hypopygium pale; eighth sternite with a long, pale, compressed, median blade; outer dististyle attenuated.

Male.—Length, about 9 millimeters; wing, 9.6.

Frontal prolongation of head yellow, only weakly darkened above; nasus elongate, reddish brown, tufted with long black setæ; palpi dark brown. Antennæ with scape light yellow, pedicel and flagellum dark brown; antenna moderately elongate, if bent backward extending to shortly beyond base of abdomen; flagellar segments moderately incised, the verticils shorter than the segments. Head yellow, the vertical tubercle clearer yellow; no sign of orbital darkening; occipital brand very small, scarcely apparent against the ground color.

Pronotum and propleura entirely pale yellow. Mesonotum pale yellow, the præscutum with three polished black stripes, the lateral pair strongly outcurved, almost reaching the lateral margin; scutum pale yellow, the lobes extensively variegated with black, the color broadly confluent across the suture with the lateral præscutal stripes; scutellum brownish black, the parascutella light yellow; mediotergite entirely pale yellow, unmarked except for the usual paired darkened spots at posterior border. Pleura pale yellow, variegated with more reddish on the anepisternum, the ventral sternopleurite, and as a semicircular area on the pleurotergite. Halteres dusky, the apices of the knobs

pale yellow. Legs with the coxæ and trochanters yellow; femora and tibiæ brownish yellow, the tips not or only very narrowly darkened; tarsi black. Wings (Plate 1, fig. 21) relatively narrow, with a very faint brown tinge; stigma oval, relatively dark brown; very narrow dark clouds on anterior cord and m-cu; wing tip very narrowly darkened; veins dark brown. Venation: Sc_1 barely indicated; Sc_2 ending just before origin of Rs, the latter subequal to R_{2+3}; cell M_1 short-petiolate; M_4 arising some distance before departure of vein M_3; m-cu a short distance before fork of M.

Abdomen yellow, the tergites with an interrupted median stripe, appearing as broad, dark brown, posterior triangles, on the outer segments small and inconspicuous; tergites very vaguely darkened on lateral portion; sternites and hypopygium pale. Male hypopygium with the tergite (Plate 4, fig. 47, 9*t*) extended into a slender, gently curved arm on either side, each bearing a tooth at near midlength of mesal face and a group of four or five others at base; intermediate spinous lobes of tergite truncated at tips, lying close together. Outer dististyle, *od*, long-attenuate, the base relatively broad. Inner dististyle, *id*, bidentate at apex of beak, one point being blackened, the other pale. Membrane between eighth and ninth sternites produced ventrad and slightly cephalad into a long, pale, compressed lobe, narrowed to the tip, the surface microscopically setulose; upon dissection, this blade is seen to be a part of the eighth sternite and is removed with it.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, August 22, 1929 (*Franck*).

The present species is very distinct in the details of coloration and structure of the male hypopygium, notably the long-attenuated outer dististyles and the pale median lobe of the eighth sternite. The structure of the hypopygium is somewhat as in the otherwise very different *Nephrotoma ligulata* Alexander (Mongolia).

NEPHROTOMA DECREPITA sp. nov. Plate 1, fig. 22; Plate 4, fig. 48.

General coloration yellow; præscutal stripes black, the surface weakly pitted to appear only feebly shining; occipital brand dark brown, poorly delimited; terminal segment of maxillary palpus orange-yellow; central portion of mediotergite darkened; legs and halteres chiefly yellow; wings subhyaline, stigma pale brown, cell Sc light yellow; abdomen orange, the tergites with

an interrupted median series of brown spots; hypopygium pale; ninth sternite with two ventral lobes.

Male.—Length, about 11 millimeters; wing, 10.

Frontal prolongation of head obscure yellow, the dorsal surface weakly infumed; nasus a little darker; palpi with basal three segments chiefly brown, the terminal segment paling to orange-yellow. Antennæ moderately elongate, if bent backward extending to shortly beyond the base of abdomen; scape and pedicel yellow, flagellum black; flagellar segments moderately incised; verticils shorter than the segments. Head yellow, the occipital brand dark brown, of moderate size, poorly delimited especially at anterior end; orbital spots barely evident.

Pronotum clear yellow, the lateral portions infuscated. Mesonotal præscutum yellow, with three black stripes, the surface weakly pitted and thus only feebly shining; stripes very narrowly bordered by more velvety black; a paler brown spot at anterior end of lateral stripe; scutum yellow, the lobes extensively blackened; lateral end of suture and outer corner of scutal lobe darkened; scutellum blackened, parascutella yellow; mediotergite light yellow, with a broad, median, brown area, more expanded at posterior border. Pleura yellow, variegated with more reddish yellow on anepisternum, ventral sternopleurite, and ventral meron: dorsal pleurotergite reddish, the lower edge of the ventral pleurotergite narrowly dark brown. Halteres almost uniformly yellow throughout. Legs with the coxæ and trochanters yellow; femora and tibiæ obscure yellow, the tips not or scarcely darkened; basitarsi yellowish brown, passing into brownish black; remainder of tarsi black. Wings (Plate 1, fig. 22) subhyaline; stigma pale brown; cell Sc and prearcular field light yellow; veins brown. Venation: Sc_1 lacking; cell M_1 sessile; M_4 departing some distance before base of cell 1st M_2; m-cu on M_4 shortly beyond origin.

Abdominal tergites orange, with a broken series of brown spots, interrupted at the incisures; sternites and hypopygium pale, the eighth sternite darkened subbasally. Male hypopygium with the tergite (Plate 4, fig. 48, *9t*) produced into two strongly divergent horns, at base of their mesal face with four or five blackened points; mesal lobes unusually slender, with abundant black spicules. Outer dististyle relatively small and slender, the tip not long-produced. Inner dististyle, *id*, with apical beak slender. Ninth sternite produced ventrad into a stout, fleshy, pale lobe; extreme posterior border of sternite with a median

ligulate darkened lobe that in a position of rest lies cephalad along the surface of the eighth sternite. This appendage appears to arise from the membrane between the eighth and ninth sternites but upon dissection actually comes from the posterior border of the ninth.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, August 15, 1929 (*Franck*).

As is usual in the genus, the chief characters for defining the present fly lie in the details of structure of the male hypopygium, especially the ninth tergite, the inner dististyle, and the peculiar lobes of the ninth sternite, the last being quite different from that of regional species.

NEPHROTOMA BIFORMIS sp. nov. Plate 1, fig. 23; Plate 4, fig. 49.

Sexes strongly dimorphic in color; males chiefly black, variegated with yellow; abdomen blackened, without reddish color; femora yellow basally, with approximately the outer half blackened; wings beyond base with a faint yellow tinge; females with only the extreme tips of femora blackened; wings uniformly and deeply tinged with amber yellow; abdomen extensively brick red; male hypopygium with a bidentate plate on caudal margin of eighth sternite.

Male.—Length, 13 to 14 millimeters; wing, 11 to 12.

Female.—Length, 15 to 17 millimeters; wing, 12 to 13.

Male.—Rostrum entirely black, including nasus and palpi. Antennæ black throughout, relatively short, if bent backward extending to about midway between the roots of the wings and halteres; flagellar segments scarcely incised; longest verticils shorter than the segments. Front deep yellow, the anterior vertex orange, the entire posterior vertex and occiput black, the occipital brand more opaque, the remainder of the darkened area more velvety; a black spot on anterior orbits opposite the narrowest point; in cases, a yellow area on posterior gena beneath eye.

Pronotum black, broadly yellow medially. Mesonotal præscutum black, the stripes more glabrous, the interspaces deep velvety black; a large, nearly circular yellow area on humerus; lateral border before suture obscure yellow; scutum black, the median portion narrowly pale yellow; scutellum and mediotergite black, the latter restrictedly obscure yellow on sides. Pleura black, variegated with yellow on the pleurotergite and very obscurely on the anepisternum and pteropleurite. Halteres

dusky, the knobs black. Legs with the coxæ dull black, pruinose; trochanters obscure yellow; femora yellow basally, with approximately the outer half or less black; tibiæ brown basally, passing into black; tarsi black. Wings (Plate 1, fig. 23) with a faint yellow tinge; stigma oval, dark brown; prearcular region and cells Sc and Cu_1 light yellow; a restricted dark seam on anterior cord; extreme wing tip very insensibly darkened; veins black, more flavous in the yellow areas. Venation: Sc_2 ending opposite or just beyond origin of the short Rs; cell M_1 sessile; M_4 variable in position, usually departing some distance before M_3, but in cases at this point; m-cu at or a short distance before the fork of M_4.

Abdomen almost entirely blackened; pruinose, without reddish coloration; extreme lateral borders of tergites and caudal margins of sternites pale yellow; hypopygium black. Male hypopygium with the tergite (Plate 4, fig. 49, 9*t*) produced into two flattened lobes that are separated by a narrow notch, the mesal edges of the lobes with slender spines and stout spinous setæ. Outer dististyle, *od*, relatively narrow, not greatly attenuated. Inner dististyle, *id*, with the margin having a series of more than a score of long erect setæ, the shorter ones more distad. Eighth sternite tranverse, the caudal margin beneath with a depressed lobe, 8*s*, that terminates in two acute black lateral spines, separated by a U-shaped emargination.

Female.—Like the male, differing as follows: Antennal scape yellow to obscure yellow. Femora and tibiæ yellow, the tips narrowly blackened. Wings strongly suffused with amber yellow, much deeper in color than in male. Abdomen chiefly brick red, the tergites velvety black medially, with very broad lateral margins of the ground color, the sixth and succeeding segments almost uniformly reddish; basal tergite uniformly blackened, pruinose; the remaining tergites with pruinose lateral margins; sternites red, the lateral borders narrowly black.

Habitat.—China (Szechwan).

Holotype, male, O-Er, 26 miles north of Li-Fan, altitude 9,000 feet, August 6 to 16, 1933 (*Graham*). Allotopotype, female, August 17, 1933. Paratopotypes, 4 males, 8 females, August 6 to 18, 1933. Paratypes, 1 female, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*); 1 male, Mu-Sang-Tsai, altitude 8,000 to 10,000 feet, July 27 to 28, 1933 (*Graham*).

The only other regional species with which the present fly may be confused is *Nephrotoma erebus* Alexander (Mongolia), which

has the black coloration even more extensive, including the whole head, and with the hypopygial structure different.

NEPHROTOMA OMEIANA sp. nov. Plate 1, fig. 24; Plate 4, fig. 50.

Allied to *palloris;* antennæ (male) relatively elongate, the flagellar segments weakly bicolorous; occipital brand small and inconspicuous; mesonotal præscutum with three brown stripes; lateral ends of suture velvety back; scutellum and central portion of mediotergite broadly pale; tips of femora narrowly blackened; wings cream-colored, variegated with brown; a conspicuous pale area beyond the stigma; m-cu far before fork of M_4; abdominal tergites trivittate with brownish black, the stripes interrupted; male hypopygium with the outer dististyle small, not attenuated.

Male.—Length, 12.5 to 13.5 millimeters; wing, 10.5 to 11.5; antenna, 5 to 5.2.

Female.—Length, 17 to 18 millimeters; wing, 13 to 14.

Frontal prolongation of head obscure yellow, polished; nasus long-tufted, somewhat darker; palpi dark brown, the central portion of the terminal segment more yellowish. Antennæ (male) relatively elongate, as shown by the measurements; basal three segments yellow; succeeding flagellar segments bicolorous, brownish black, the outer ends of the segments narrowly yellow, the basal enlargements a little more intensely black; outer segments more uniformly darkened; flagellar segments rather strongly incised; terminal segment small, thimble-shaped. Head orange; occipital brand small, pale brown, inconspicuous.

Pronotum obscure yellow, a little darker on sides. Mesonotal præscutum yellow, with three brown stripes, their surface subnitidous, without darker margins; lateral stripes straight; scutum broadly yellow medially, the lobes entirely black; lateral ends of suture and extreme anterolateral corners of scutal lobes narrowly velvety black, forming a strongly curved mark; scutellum pale, parascutalla dark; mediotergite broadly pale yellow medially, darker laterally and behind. Pleura pale yellow, darker, more reddish, on the anepisternum and sternopleurite, forming an oblique or transverse girdle across mesopleura. Halteres yellow, the knobs weakly infuscated. Legs with the coxæ obscure yellow; trochanters yellow; femora yellow, the tips very narrowly but conspicuously blackened; tibiæ yellowish brown, brighter basally, the tips darkened; tarsi passing through brown to black. Wings (Plate 1, fig. 24) with the ground pale cream colored; prearcular region darkened; cell Sc

dark brown, C more brownish yellow; stigma oval, dark brown; wing tip broadly and conspicuously darkened, the color extending from cell R_2 to cell M_3, separated from the dark stigmal area by a pale marking in cells Sc_2 and R_2; anterior cord and m-cu conspicuously seamed with brown; distal section of Cu_1 less conspicuously seamed with brown; veins dark brown. Venation: Sc_2 ending opposite the short Rs, Sc_1 represented by a short spur; cell M_1 petiolate; cell 1st M_2 relatively small; m-cu some distance before fork of M_4.

Abdomen (male) elongate, yellow, the tergites narrowly trivittate with brownish black, the median stripe interrupted basally, the lateral stripes subbasally, on each segment; sternites yellow, narrowly darkened medially, more extensively so on the outer segments, the incisures pale; hypopygium yellow. Male hypopygium relatively large; tergite (Plate 4, fig. 50, 9*t*) proportionately small, gradually narrowed outwardly, with blackened spiculose points on either side of a deep U-shaped median notch but without other armature. Outer dististyle, *od*, small, triangular in outline, the tip not produced. Inner dististyle, *id*, as figured. Eighth sternite narrowly but rather deeply notched, with moderately conspicuous dark brown setæ surrounding the notch, their tips converging.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, August 14, 1929 (*Franck*). Allotype, female, Chunking, altitude 1,000 to 2,000 feet, May 6 to 27, 1930 (*Graham*). Paratopotype, male, August 10, 1929 (*Franck*). Paratypes, 8 males and females, with the allotype; 2 males, 1 female, Kwanhsien, May 8 to 28, 1930 (*Graham*).

The nearest allies of the present fly are *Nephrotoma palloris* (Coquillett) and *N. sinensis* (Edwards), both of which have the postnotal mediotergite broadly pale, except laterally. The present fly differs most evidently in the three præscutal stripes, pale costal spot beyond the stigma, and the details of structure of the antennæ and male hypopygium.

ILLUSTRATIONS

[Legend: *b*, Basistyle; *d*, dististyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite.]

PLATE 1

FIG. 1. *Tipula* (*Brithura*) *argyrospila* sp. nov., venation.
2. *Tipula* (*Brithura*) *fracticosta* sp. nov., venation.
3. *Tipula* (*Nippotipula*) *sinica* sp. nov., venation.
4. *Tipula* (*Sinotipula*) *exquisita* sp. nov., venation.
5. *Tipula* (*Sinotipula*) *gloriosa* sp. nov., venation.
6. *Tipula* (*Formotipula*) *omeicola* sp. nov., venation.
7. *Tipula* (*Formotipula*) *friedrichi* sp. nov., venation.
8. *Tipula* (*Acutipula*) *melampodia* sp. nov., venation.
9. *Tipula* (*Acutipula*) *bistyligera* sp. nov., venation.
10. *Tipula* (*Vestiplex*) *testata* sp. nov., venation.
11. *Tipula* (*Oreomyza*) *famula* sp. nov., venation.
12. *Tipula* (*Oreomyza*) *tetramelania* sp. nov., venation.
13. *Tipula* (*Oreomyza*) *rudis* sp. nov., venation.
14. *Tipula* (*Oreomyza*) *haplorhabda* sp. nov., venation.
15. *Prionocera lætipennis* sp. nov., venation.
16. *Prionocera altivolans* sp. nov., venation.
17. *Nephrotoma retenta* sp. nov., venation.
18. *Nephrotoma attenuata* sp. nov., venation.
19. *Nephrotoma impigra* sp. nov., venation.
20. *Nephrotoma pilata* sp. nov., venation.
21. *Nephrotoma immemorata* sp. nov., venation.
22. *Nephrotoma decrepita* sp. nov., venation.
23. *Nephrotoma biformis* sp. nov., venation.
24. *Nephrotoma omeiana* sp. nov., venation.

PLATE 2

FIG. 25. *Tipula* (*Brithura*) *fracticosta* sp. nov., male hypopygium, details.
26. *Tipula* (*Brithura*) *fractistigma* Alexander, male hypopygium, dististyle.
27. *Tipula* (*Nippotipula*) *sinica* sp. nov., male hypopygium, details.
28. *Tipula* (*Sinotipula*) *exquisita* sp. nov., male hypopygium, details.
29. *Tipula* (*Sinotipula*) *gloriosa* sp. nov., male hypopygium, details.
30. *Tipula* (*Sinotipula*) *gloriosa* sp. nov., male hypopygium, dististyles.
31. *Tipula* (*Sinotipula*) *persplendens* sp. nov., male hypopygium, dististyles.
32. *Tipula* (*Formotipula*) *friedrichi* sp. nov., male hypopygium, details.
33. *Tipula* (*Acutipula*) *melampodia* sp. nov., male hypopygium, ninth tergite.
34. *Tipula* (*Acutipula*) *melampodia* sp. nov., male hypopygium, details.

PLATE 3

FIG. 35. *Tipula* (*Acutipula*) *bistyligera* sp. nov., male hypopygium, details.
36. *Tipula* (*Vestiplex*) *testata* sp. nov., male hypopygium, details.
37. *Tipula* (*Oreomyza*) *famula* sp. nov., male hypopygium, details.
38. *Tipula* (*Oreomyza*) *tetramelania* sp. nov., male hypopygium, details.
39. *Tipula* (*Oreomyza*) *rudis* sp. nov., male hypopygium, details.
40. *Tipula* (*Oreomyza*) *rudis* sp. nov., male hypopygium, details.
41. *Prionocera lætipennis* sp. nov., antenna, male; basal six segments.
42. *Prionocera lætipennis* sp. nov., male hypopygium, details.

PLATE 4

FIG. 43. *Nephrotoma retenta* sp. nov., male hypopygium, details.
44. *Nephrotoma attenuata* sp. nov., male hypopygium, details.
45. *Nephrotoma impigra* sp. nov., male hypopygium, details.
46. *Nephrotoma pilata* sp. nov., male hypopygium, details.
47. *Nephrotoma immemorata* sp. nov., male hypopygium, details.
48. *Nephrotoma decrepita* sp. nov., male hypopygium, details.
49. *Nephrotoma biformis* sp. nov., male hypopygium, details.
50. *Nephrotoma omeiana* sp. nov., male hypopygium, details.

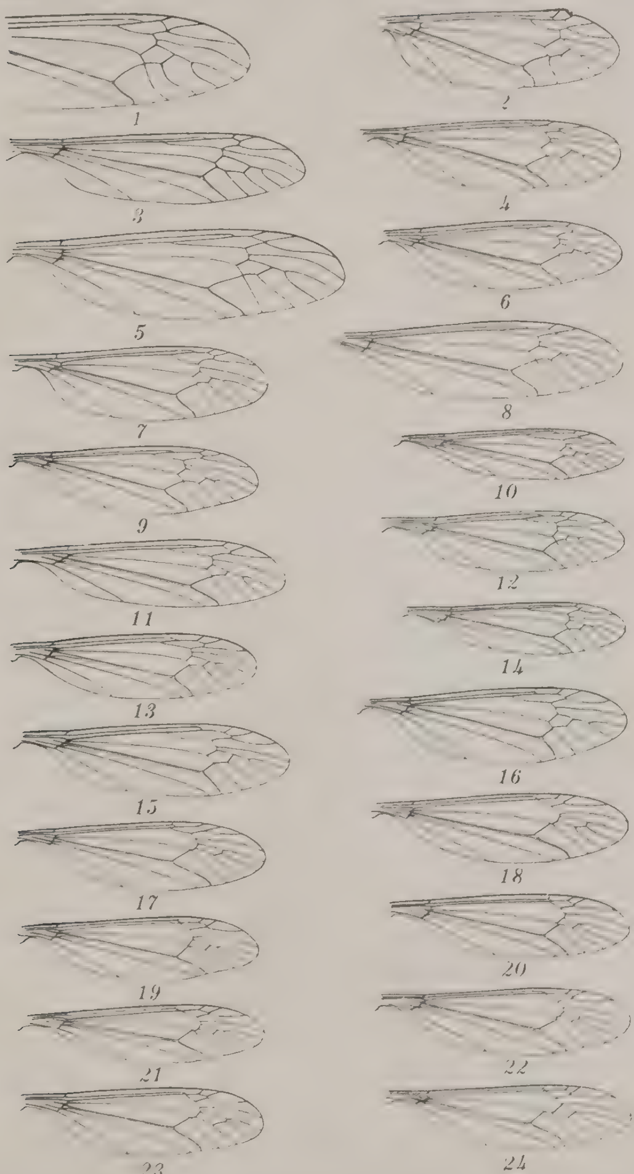

PLATE 1.

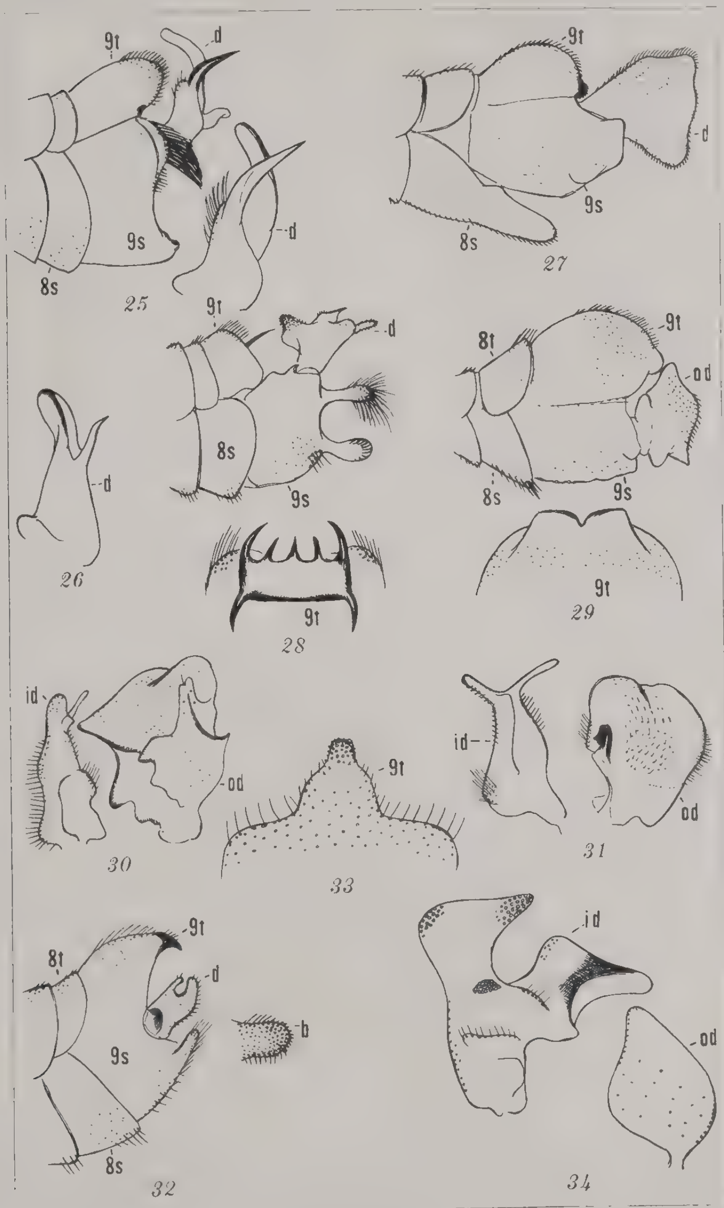

PLATE 2.

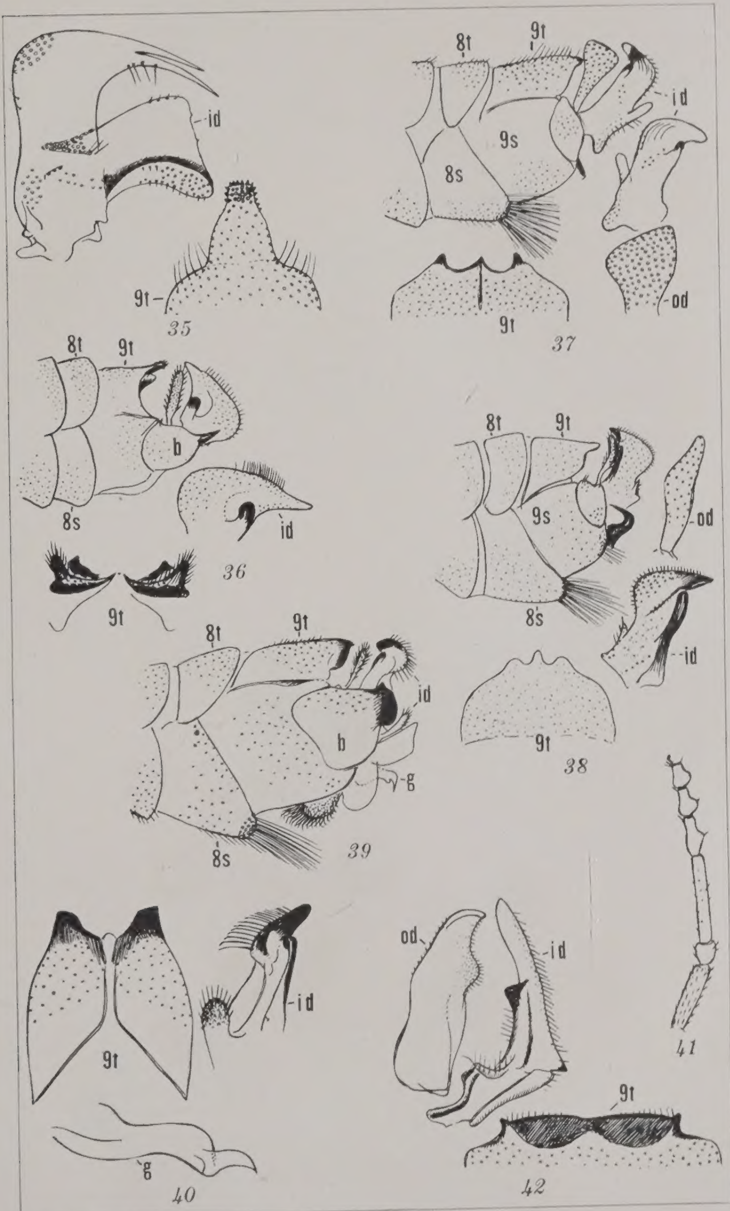
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PLATE 3.

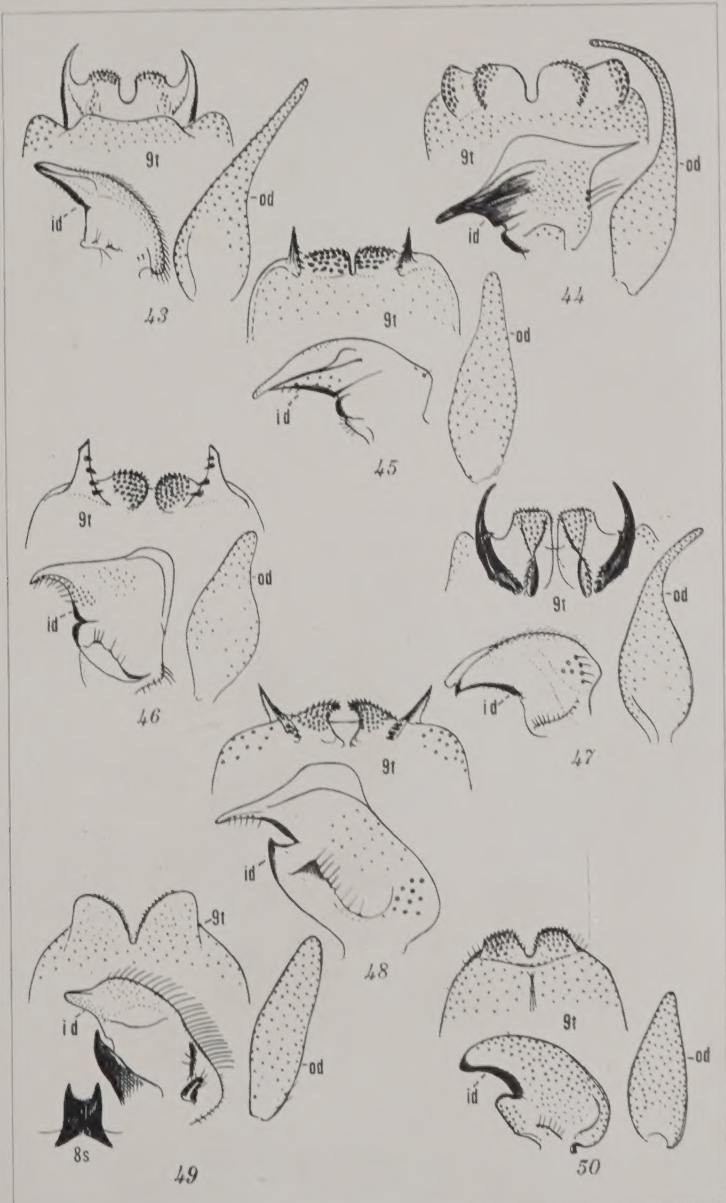

PLATE 4.